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SHRIMP RESOURCES IN THE SEAS AROUND THE ASIAN COUNTRIES WITH SPECIAL REFERENCE TO INDIA

BY

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PREFACE

This study on "Shrimp Resources in the Seas Around the Asian Countries with special reference to India" by Dr.M.J.George, Retd.Joint Director, CMFRI, Cochin is sponsored by the Programme for Community Organisation. India has been one of the top ranking countries in the world in shrimp production. But a stage has set in where further increase in production appears to be quite bleak, unless new resources are located probably in deeper waters or through aquaculture. Hence is the importance of the study.

Dr.George, a well known prawn fishery expert in the country, in his study has examined the ecological and environmental factors, influencing fish and prawn biomass including primary productivity, etc. He has provided a detailed account of the trend in fish and shrimp production in Asian Countries in general and in India in particular. The author has also made a probe into the biology of shrimp fishery of India, their migrational habits and the technologies adopted for exploitation. A section of the report is devoted to analyse the concept of over-fishing of shrimps viewed from the biological and economic premises.

We are grateful to Dr.George for bringing out a comprehensive analysis of prawn fisheries in India and the seas around the Asian Countries. We hope this document will prove to be a valuable material for all those who are concerned with policy decisions for proper conservation and management of the resource. It will also be a good addition to the scientific literature on the subject.

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1. INTRODUCTION

World fisheries statistics reveal that among the shrimp producing countries of the world India has reached the top rank in production in 1973 and this was kept up till 1983. From 1984 China has taken over the position. The tropical waters around the world produce the maximum quantity of shrimps, mainly constituted by the shrimps of the family penaeidae and the waters around the Asian countries are specially productive in these shrimps. However, the demand for these shrimps and marine shrimp products from the export industry of most of these countries is so high that every country is exploring all possible measures for the maximum exploitation of the resources available in their different coastal waters. It would appear that a stage has come in some of the Asian countries like India where the landings from the availabl resources has levelled off and further increase in production seem to be quite limited, unless new resources are located probably in deeper waters or by developing suitable techniques for increasing production by squaculture of shrimps.

Mechanisation of the fishery and introduction of shrimp trawling is the most important development in the exploitation of shrimp resources. It has contributed significantly to the increase in shrimp production in most of the developing third world tropical countries during the past two decades. In some countries, like India, a stage has been reached in several coastal areas where this additional input of effort, using mechanised trawling, after paying off well in the initial stages in exploiting some of the shrimping grounds outside the reach of the traditional artisanal fishing sector, is now exhibiting signs of stagnation in the level of exploitation. In some countries a steady decline in the yields is also perceived. This should definitely be a matter of concern from the point of view of conservation of the fishery.

The stagnation in production or decline in the yield may be brought about by various factors such as limitations in the available resources; indiscriminate input of effort in exploitation of the fishery; and variations in the ecological and environmental factors caused by pollution or natural phenomena. It is the combination of these factors that usually plays the important role in bringing about stagnation in yield levels. When resources are exploited by adjoining countries, the single stock being exploited by them will also have to be taken into consideration to determine the optimum level of yield. In order to arrive at some dependable conclusion regarding the management techniques to be adopted in conserving the fishery at a sustainable level, a thorough analysis of the available resources, the trends in production, biological and economical tendencies in the exploited fishery and the various other features is essential. This paper is the result of such an approach.

2. THE PRODUCTIVITY AND OTHER ECOLOGICAL CHARACTERISTICS OF THE SEAS AROUND ASIAN COUNTRIES.

Studies made during the International Indian Ocean Expedition (IIOE) during 1960-65 have revealed that there are several areas in the Indian Ocean and adjacent tropical seas which are exceptionally rich in nutrients, chlorophyll, organic production and zooplankton biomass. Consequently these areas can sustain large stocks of fishery resources. The shallow water areas in the Indian Ocean form about 3.1 million sq.km. The shelf areas vary in width as well as surface contour. The red sea and Gulf of Suez are bounded by narrow reefs. Gulf of Persia is extremely shallow. The west coasts of Pakistan India and Sri Lanka have wider shelves whereas on the east coast except the upper region the shelves are narrow. The coasts of Bangladesh, Burma, Thailand and Malaysia have wide shelves with mangrove swamps.

The Carbohydrates which form the first link in the food chain synthesised by the microscopic floating algae such as diatoms, dinoflagellates, flagellates and various other minute organisms of phytoplankton in the lighted zone of the water bodies is termed as primary productivity or organic production. This can be measured either by the oxygen liberated during photosynthesis or carbon dioxide assimilated through radio isotope of carbon. The organic production ultimately forms the potential energy at different trophic levels including benthic fauna. In the intensely exploited waters 0.4% of the primary production expressed as carbon forms the maximum sustainable yield.

Chlorophyll 'a' is the major component of the phytoplankton that synthesises the carbo hydrates using the energy from the electromagnetic spectrum of the sun. The chlorophyll can be measured either by spectrophotometer or recently by suitable sensors founded on satellite so that the production potential of the water bodies can be determined by remote sensing techniques. Chlorophyll 'a' is expressed in terms of milligram per metre cube (mg/m^3). The primary productivity is expressed as gram carbon per sq. metre per day ($g^c/m^2/day$).

As the concentration of phytoplankton pigments gives a direct estimate of the magnitude of the standing crop, the pattern of distribution of the pigment especially Chlorophyll 'a' in the sea gives a broad outline of the potential resources. An excellent correlation between temperature, nutrients like phosphates, primary production and zooplankton biomass has been reported by several authors. Prasad (1966) and Kabanova (1968) have reported and discussed the productivity of the Indian Ocean region including the waters of all the Asian countries bordering the ocean. Later Cushing (1971) compiled all the primary productivity data for the Indian Ocean Fisheries Commission of Food and Agriculture Organisation on the survey of resources in the Indian Ocean and Indonesian area. A summary of this is given in Table 1.

In general, in the western Indian Ocean region during the south west monsoon, extremely high values of productivity are found. High values of primary production and zooplankton biomass are observed in this area. Such high values are not found during the north east monsoon period. But in the Red Sea a considerable increase in the integrated pigment values is observed. The distribution pattern of chlorophyll ' a ' shows that the level of pigment concentration per unit area is almost the same as that of Atlantic and Pacific Oceans.

According to Prasad and Nair (1971) there is a great amount of spatial variation in the magnitude of organic production in the Indian Ocean. The shelf areas which sustain the bulk of the resources on the whole have a higher rate of production. An average rate of 0.5 to 1.0 g^C/m^2/day is observed in most of the shallow areas. Higher rates are found during upwelling periods in nearshore areas around south east and south west coast of India. In the Arabian sea the level of organic production increases to the north and west, reaching exceptionally high values off the coasts of Saudi Arabia and Pakistan. The Arabian Sea, when considered as a whole, is a region of great contrast. The North western Arabian Sea showed values in excess of 1.0g^C/m^2/day. In the eastern Arabian Sea towards the coast of India the average rate within 50 m depth is about 1.19 g^C/m^2/ day. For the Bay of Bengal the average production rate is 0.19 g^C/m^2/day in the deeper part while in the shelf region it is 0.63 g^C/m^2/ day. Based on these primary productivity figures and other related environmental features estimations of potential fish resources have been made by various authors which will be dealt with in the ensuring section.

3. ESTIMATED RESOURCES IN RELATION TO PRIMARY PRODUCTIVITY AND OTHER FEATURES.

Prasad et al (1970) calculated that the annual net production for 51 million sq.km. of the Indian Ocean would be 3.9×10^9 tonnes of carbon. Of this 2.3×10^9 tonnes of carbon

is for the eastern region comprising of 29 million sq.km. and 1.6×10^9 tonnes of carbon for the eastern region with 22 million sq.km. with the dividing line at $80^{o}C$ longitude. The continental shelf areas which form only 6% of the total area account for 560×10^6 tonnes of carbon for 14% of the total net production. Of this, the Indian coastal region contribute 61 million tonnes which is roughly 1 tonne per hectare. The calculation, based on the results of estimates obtained in North Sea and other heavily exploited areas, is that for a production of 1.2 g^C/m^2/day the annual potential yield of fish is about 105 kg. per hectare.

The potential yield of fish for the entire continental shelf area of India as derived from productivity studies, has been found to be 2,288,000 tonnes, of which the share of the west coast is 1,417,000 tonnes according to Jones and Bannerji (1968). Prasad and Nair (1971) have split this potential resource of the Indian shelf area into pelagic and demersal potential yields - about 1,600,000 tonnes pelagic and 700,000 tonnes demersal catches including shrimps. Examining the theoretical estimations of potential resources in the light of various exploratory fishing data available through different publications from different areas Prasad and Nair (1971) give consolidated figures of the potential resources of the various regions (See table 2).

Various other projections on the potential resources of Indian Ocean region are available. The Food and Agriculture Organisation of the United National (FAO) (Gulland 1971) has given 14.3 million tonnes as the potential yield of the region, distributed as 7.4 million tonnes as demersal fishes 6.7 million tonnes of pelagic fishes and 0.25 million tonnes of Crustaceans and an equal amount of squids and cuttle fishes. Nair et al (1971) indicated a minimum potential yield for the Indian Ocean of 14.4 million tonnes with 9.6 million tonnes for the shelf areas.

Taking all these projections George et al (1977) have drawn the conclusion that the potential yield of the Indian Ocean appears to be between 10 and 14 million tonnes.

The total estimated exploitable yield of fishes from the Indian continental shelf has been given as 2.3 to 2.6 million tonnes.(Jones and Banerji , 1968; Prasad et al 1970; Nair et al., 1973; Antony Raja, 1974). Combining all the methods used by earlier authors George et al (1977) employed three alternatives for calculation of potential resources of Indian continental shelf waters and got 3 figures namely, 2.7 million tonnes 5.0 million tonnes and 3.7 million tonnes. Making a choice of the correct figures from these three alternatives they were of opinion that the potential exploitable yield of the Indian continental shelf waters may be any where between 2.7 and 3.7 million tonnes. In a projection of the potential resources of the entire Exclusive Economic Zone (EEZ) of India they ended up with a figure of 4.5 million tonnes of harvestable living resources consisting of both conventional and non-conventional elements.

In a recent attempt to make a review of the exploited resources and the potential yields of the EEZ of India and the various regions James et al (1986) gave the revised break up of the estimated potential yield of different regions and depth zones vis a vis present production as presented in the tables 3 and 4. The potential yield of 4.47 million tonnes comprise of pelagic fishes - 1.85 million tonnes, demersal fishes - 1.1 million tonnes and the rest made up of crustacean, cephalopods, oceanic fishes and miscellaneous fishes (Table 4).

From the table it may be seen that the regionwise potentials show increased scope for production from the north east region as compared to other regions within the 50 m depth zone. The potential from the 50-200 m depth zone and Oceanic waters offers vast scope for exploitation amounting to nearby

2.2 million tonnes. In a break up of the potential resources of crustaceans, James et al (op.cit) have given 111,000 tonnes and 57,000 tonnes of current yield of penaeid shrimps and non penaeid shrimps and 180,000 tonnes and 105,000 tonnes respectively of potential yield.

4. SHRIMP RESOURCES OF ASIAN COUNTRIES AND INDIA

Trends in fish and shrimp production in Asian countries

In order to get an idea of the total crustacean production in Asian countries as a whole in comparison with the total world fish production, these details are given in Table 5. The trends in production from the year 1977 to 1985 are seen in the table. In the world fish production there is a steady increase from 68.2 million tonnes in 1977 to nearly 76.5 million tonnes in 1983. The total inland fish production in Asian countries shows the same increasing trend from 4.2 million tonnes in 1977 to 5.75 million tonnes. The marine fish production in Asian countries also indicate the same increasing trend from 25.7 million tonnes in 1977 to 29.01 million tonnes in 1983. The total crustacean Production with both inland and marine production put together steadily increases from 2.7 million tonnes in 1977 to 3.2 million tonnes in 1983. From 1983 to 1985 there is still further increase in all these.

The total fish production in the different countries of Asia during the years 1977 to 1985 is shown in table 6. The total fish production in India increases steadily from 2.31 million in 1977 to 2.81 million tonnes in 1985. It may be seen that Japan ranks first and China second in the total fish production. India has the third position among the Asian countries in total fish production. Korea comes next in position.

A picture of the total shrimp production during the years 1980 to 1985 in the shrimp producing countries of Asia is seen in table 7, the figures representing the totals of both inland and marine shrimp landings. A study of the table would show that India ranks first in shrimp production among the Asian countries, although a slight reduction over the years 1980 to 1985 is noticed in the production. China, Thailand and Indonesia comes next in production in that order. From 1984 China takes first rank.

Gulland and Rothschild Ed(1984) have given review papers on the shrimp fishery of some of the Asian countries including India. Brief summaries taken from this publication on the shrimp fishery of some of the Asian countries are given below.

China: Ye Chang Chang (1984) has described the substantial shrimp fishery of Pohai Sea and Yellow Sea contributed by the species Penaeus orientalis or P. chinensis. The species makes extensive migrations of nearly 1000 km from its nursery grounds in the inner pohai sea to wintering grounds in the deeper waters of the Yellow sea, returning to spawn in the pohai sea in April-May. This gives rise to 3 distinct fishery seasons, in autumn and spring in the pohai sea and in winter-spring in the yellow sea. Most of the catches are taken in the autumn using set nets from small vessels of less than 40 hp, and trawls operated by larger vessels upto 200 hp doing pair trawling. Catches have fluctuated between 10,000 tonnes and 90,000 tonnes during the years 1965 to 1980 mainly due to variation in recruitment.

Management measures are currently in force to protect the brood stock and young prawns, based on a bio-economic model, which includes the effects of growth and natural mortality of the population and the costs of fishing, determining the optimum fishing strategy. Protection of brood stock is achieved by unilateral closed fishery for prawns in the spring fishing season in the sea north of Chengshanton of Shandong province.

The regulations stimulate that the opening date for the autumn fishing seasons is 15th September. But the amount of fishing boats or the effort is not strictly controlled. The study (Ye Chang Cheng 1984) based on bioeconomic model shows that it is fundamentally reasonable to set the date of commencement of fishing as 15th September. But control of fishing effort is equally important for proper management. For this purpose the study has put forward three goals of management and their corresponding fishing efforts. These goals of management are in conflict with each other, and their corresponding optimum efforts also differ greatly from each other. If it is intended to obtain the optimum economic result in the fishery, it is necessary to cut down the fishing effort but if the goal is to increase employment opportunities, economic benefits has to be sacrificed and power consumption increased. It is not possible to have both at the same time. In essence, the prawn fishery management involves the distribution of yields, economic results and resources, and many politically and socially complicated factors. The article provides scientific data analysis on bioeconomic models and 3 alternatives for different goals of management mentioned above and their corresponding results worked out. The author leaves it to the policy-maker to work out a feasible and satisfactory management plan based on the factors and optimum conditions presented in the study. However, the only management measures being implemented at present is the closed season for the young prawns in the spring and the opening of the fishery for the adults in the autumn season by 15th of September.

Indonesia: Total catches of shrimp in Indonesian waters have totalled over 100,000 tonnes annually with peak export earnings of over U.S. $200 million in 1980. Shrimps of the family penaeidae are caught both by a variety of traditional gears and by relatively modern waters. Although 42 species of

shrimps are found in these waters, about a dozen species of penaeid shrimps contribute to the major fishery, 6 penaeid species of the genus penaeus, 3 species of Metapenaeus and and 3 species of Parapenaeopsis. Out of these penaeus merguiensis, Metapenaeus ensis and parapenaeopsis coromandelica constitute the bulk of the catch. In addition small sergestid and Mysid shrimps also play important role in the production and diet on a national scale, being used to prepare the shrimp paste which is widely used in the daily food.

Shrimp are caught both by a variety of traditional gears such as tidal trap, lift net, gill net, Danish seine, beach seine and push net as well as modern trawl nets operated by trawlers. This had led to conflicts between the two groups, namely mechanised and non-mechanised sectors. Depletion and over exploitation in the fishery has been observed along with decrease in size of shrimps, in areas like Malacca Strait, east kalumantan Arafura sea etc. These developments have led to a series of management measures from 1973 onwards. From January 1981 trawling has been completely banned through Indonesia except in the eastern waters, as per the general objective of the Indonesian National Plan, which are to increase fish production, to improve the livelihood of fishermen, to increase employment opportunities and to maintain the biological yield of the resources (Unar and Naamin 1984).

Before the banning of shrimp trawl operations, trawlers were encouraged to transfer their operations to other fishing gear, such as purse seining, gill netting or even skipjack pole and line fishing, and soft loans were provided to those who needed them. After the banning was implemented, soft loans were also provided to small scale inshore fishermen to be able to equip their small vessles with engines and new fishing gear. This was a crash programme to modernise their fishing operations to take advantage of the reduction in total effort. Landings can be expected to increase accordingly.

In certain shrimp landing centres on the south coast of Java and other areas, where formerly trawling was the predominant gear, shrimp catch dropped by about 80 percent and thereafter the catches are found to be increasing and they are still on the rise. In the areas where trawling has been banned, surveys are carried out to observe new developments in fishing gear, shrimp landings and socio-economic aspects of the shrimp industry. Bottom gillnetting for shrimp is developing in most banned areas. Experimental fishing conducted in these areas about ten months after the banning was implemented gave remarkable high catches of shrimp, showing that the stock is recovering. The highest percentage of shrimp workers suffering from the banning are those who were involved in post harvest activities, such as processing and marketing in areas where trawling was concentrated such as in the north sumatra province. The need of designing new management alternatives in shrimp fisheries for such areas is urgent. However, more details on the recovery of the fishery after the implementation of banning of shrimp trawl operations, and data on shrimp landings in these areas after 1981 are not available.

Gulf between Iran and the Arabian peninsula:

According to Van Zalinge (1984) the catches of shrimp in the Gulf area are dominated by a single species penaeus semisulcatus. Production by large scale industrial fleets expanded rapidly in 1960s. In Iran landings reached a top of 9600 tonnes in 1964-65 and in Kuwait maximum of 3325 tonnes in 1966-67. In industrial landings from Saudi Arabia/Bahrain waters were also quite high in this time, reaching the maximum of 7400 tonnes in 1973-74. After this period there is a general decline in these waters in the industrial fishery, as can be noticed in the total catch figures given in Table.7. A conspicuous fall in recruitment and total catch is evident. Conservation of the fishery and proper management measures have become necessary. Most countries

have introduced a closure of the fishery for varying lengths of time at the beginning of the fishing season in the period February to June. This method of closed season is followed by Saudi Arabia, Kuwait, Bahrain, Qater and the United Arab Emeratus and Iran.

Trends in marine shrimp production in India

A study of the trend in the total production (Table 8 & Fig.1) of shrimp from the mechanised and non-mechanised sectors over the past 25 years shows that from 1962 through 1968 the catch remained below 100 thousand tonnes, although increasing at a steady level. From 1969 onwards to 1973 there was a steep increase, the catch almost doubling by this time. After 1973 there was fluctuation from year to year, the production decreasing in 1974 to 170 thousand tonnes, reaching the maximum of 220 thousand tonnes in 1975 and again going down to less than 200 thousand tonnes in subsequent years. The shrimp production figures for 1979 stands at 1,77,582 tonnes. It further declines to 1,44,969 tonnes and 1,61,945 tonnes respectively in 1981 and 1982 and again rises to 1,92,012 tonnes and 1,88,211 tonnes in 1984 and 1985 respectively. The trend in triennial average catch (using 1962-64 as base period) shows an overall increase of above 125% in the landings from 1962-64 to 1972-76, declining thereafter to slightly less than 100% in 1977-79, 85% in 1980-82 and rising again to nearly 120% in 1983-85.

Production from west and east coasts of India

It is a well known fact that the west coast of India accounts for over 80% of the total marine prawn landings. As a result, the trend in the catches of this coast determines the trend in the total landings. This is clearly seen in the trend of catches of west coast, remaining at a steady level upto 1968, thereafter, showing steep increase upto 1973 and then fluctuating during the subsequent years with a declining trend. The percentage of increase and decrease in the triennial average over the years is the same as that of the total landings.

The picture of the trend in catches along the east coast is quite different. Forming only less than 20% of the total landings, the catches remained below 12 thousand tonnes upto 1966. In 1967, a sharp increase to above 24 thousand tonnes is noticed and this is kept up in the subsequent year also. Then, there is a steep decline through 1972 to the 1966 level. Once again, the catches rise and reach the maximum of above 28 thousand tonnes in 1975 with slight reductions in 1978 and 1979. Although there is a sharp decline in the catches during 1970-72 the overall increase in percentage in the triennial average is about 150.

It may be pointed out here that although the quantity of prawns landed along the west coast is much higher than that of the east coast, the species like penaeus monodon and P. Semisulcatus with comparatively much higher unit values are landed more from the east coast. Hence, valuewise the production of shrimp on the east coast is of a much higher order than that the quantitative figures of landings alone would indicate.

Statewise production of shrimp

The major contribution of the fishery being from the west coast, the general trend in the total production is set by the landings of this coast, in which Maharashtra and Kerala states account for the bulk of the catch (Table 9). Along Kerala and Karnataka coasts the highest catches were recorded in 1973 and 1974 respectively with subsequent decrease. In Kerala slight improvement was noticed from 1976 onwards, but during 1979 there was a decline, reaching an all time low in the previous eleven years showing improvement again in 1980. In Karnataka there was considerable improvement in landings in 1978, but going down in 1979 and 1980. On the east coast both Andhra Pradesh and Tamil Nadu show significant improvement in shrimp landings in recent years.

An idea of the quantity of non-penaeids in the total shrimp fishery can be obtained from Fig. 1. While the non-penaeid prawns contribute to most of the landings in Maharashtra, the catches are exclusively contributed by penaeid prawns along Kerala coast. Along the Gujarat coast also the catches are partly contributed by non-penaeid prawns. On the east coast, while non-penaeid prawns contributed very little in the fishery in Tamil Nadu, fairly good representation of these prawns is seen in the catches of Andhra Pradesh. Thus it is seen that in Maharashtra state in the west coast and Andhra Pradesh on the east coast large quantities of non-penaeid prawns contribute to the shrimp fishery.

Apart from the taxonomical difference between these two types of prawns belonging to different families, the most important single factor of commercial significance which differentiates these prawns is the size, the non-penaeid prawns being very much smaller in total length compared to the other penaeid prawns. The total length of the most dominant non-penaeid prawn in the fishery, namely Acetes indicus along Maharashtra coast does not exceed 3.0 or 3.5 cm. Another significant factor to be noted in the shrimp production of India is that it is in the areas where only penaeid shrimps contribute to the fishery that depletionary tendencies are evident, probably brought about by the ever increasing demand for the exportable varieties of shrimps and consequent over exploitation.

5. BIOLOGY OF SHRIMP FISHERY OF INDIA

Brief reviews of the biology of the important species of shrimps contributing to the fishery of India, documented in various publications are given in Appendix 1. About 62 species of shrimps of the family penaeidae, of which some are either commercially exploited at present or have great commercial

potentialities, occur in the Indian waters. The others belong to families Sergestidae, Palaemonidae, Oplophoridae, Hippolytiadae, Pandalidae and Atydae, all grouped under non-penaeid shrimps. Both penaeid shrimps and non-penaeid shrimps are represented in the fishery. However, the non-penaeid shrimps being very small in size are not at all important from the export point of view, but only used for local consumption.

The distribution of the species in different areas of the coast is significant, details of which may be obtained from the Appendix. However, an important point worthy of mention here is that non-penaeid shrimps contribute to a large extent in the fishery of Maharashtra state in the west coast and Andhra Pradesh on the east coast. In other areas the penaeid shrimps almost exclusively contribute to the shrimp fishery except in Gujarat, where also non-penaeids are present to some extent. Among the penaeid shrimps Parapenaeopsis stylifera, Metapenaeus dobsoni, Metapenaeus affinis, Metapenaeus monoceros, penaeus indicus, Penaeus semisulcatus, Penaeus merguiensis, Penaeus monodon and Solenocera crassicornis are the most important. Of the non penaeid shrimps Acetes indicus, Nematopalaenon tenuipes, Exhippolysmata ensirostris and Exopalaemon styliferus are the dominant species. Break up of important species in the shrimp catches of the country and their percentages during the years 1980 and 1981 are given in Table 10.

The top ranking position in abundance is taken up by P. stylifera, or M. dobsoni or A. indicus varying from year to year. As indicated in the table, while P. stylifera was dominant in 1980 A. indicus was the dominant species in 1981, mostly harvested from Maharashtra, Andhra Pradesh and Gujarat. The most significant feature in the distribution of shrimp species along the regions of Indian coast line is the similarity between the coasts of Maharashtra and Andhra Pradesh, non-penaeids being represented in large abundance and the number of species of penaeids also quite high.

6. MOVEMENT AND MIGRATION STUDIES ON SHRIMPS BY MARK RECOVERY EXPERIMENTS.

Tagging of different species of shrimps in the fishery was initiated in CMFRI in 1972 by using the Petersen disc tagging method. A total of 3,189 tagged shrimps, mostly Penaeus indicus, Metapenaeus dobsoni, M. affinia, and M. monoceros were released from Goa (424 numbers), Cochin (1564 numbers) and Madras (1201 numbers) between 1972 and 1974. A recovery of 2.1% was obtained, indicating localised movements, ranging to a maximum of 19 km from the place of release, except a specimen of M. dobsoni recovered 60 km away from the spot of release and another 25 km away after a period of 10 and 8 days from release respectively. In all these places none of the shrimps released in the backwaters were recovered from the sea.

During the years 1976 to 1980 more concentrated efforts were made in tagging of shrimps at Cochin using the loop tag and releasing them in the sea as well as in the backwaters. Out of a total of 15,830 shrimps P. indicus and M. dobsoni released in the sea off Cochin, 1.6% were recovered, all of them within a period of a fortnight after release and upto 10 km from the site of release, indicating only extremely limited movement. From 38,233 juvenile shrimps released in the backwaters of Cochin during these years only 0.8% was recovered. Among these recoveries only 6 specimens of P. indicus were obtained from the sea.

Although these results may probably be taken as pointing to the fact that the emigrant shrimps from the backwaters of Cochin are not the sole support of the shrimp fishery in the sea and that part of the brood produced in the sea remains there itself, only part of it imigrating into the inside waters, further confirmatory evidence is necessary.

Extensive tagging experiments conducted by CMFRI through the National tagging programme during the years in 1981 and 1982 has yielded valuable information on migration of shrimps.

The loop tag made up of coloured plastic strip 18 mm long, 3 mm wide and 0.5 mm thick was the tag used in the studies. The method of tagging and some of the important results obtained by tagging experiments are given in detail in MFIS No.5 (1982). In the earlier years the thrust was to study the emigration of the shrimps P. indicus and M. dobsoni from Cochin backwaters and to determine how much the shrimp fishery off Cochin is sustained by emigration from the Cochin backwaters. The small percentage of recoveries of tagged shrimps in this study indicates that only a fraction of shrimp population from the Cochin backwaters contributes to the stock that supports a year long shrimp fishery off Cochin. Obviously the marine shrimp stock is sustained by inputs from other sources also, either by ingress from elsewhere or by self replenishment or both. Here the probability of part of the shrimp population, the composite species of which utilise the estuaries as nursery grounds, completing the life cycle in the sea itself cannot be ruled out. In fact it may have to be concluded that this is taking place.

Some results obtained by long distant recoveries of P. indicus tagged and released in Cochin harbour area and recovered from Tinneveli coastal waters on the east coast upto a maximum of 380 km away from Cochin after a lapse of about 60 to 100 days, definitely throw new light on the migration of this species and raises several questions as the stock and recruitment of this shrimp in the fishery at different places including the south east coast. One significant point emerging from this long distant tagged shrimp recoveries is that atleast part of the fishery of P. indicus along the south east coast, if not the whole, is supported by a stock recruited from Cochin area. However, these recoveries raise more questions than answers. For instance, one question is what part of the population of P. indicus occurring in Cochin area undertakes the southerly migration and contributes to the fishery on the south east coast? The answer to this question is essential to determine the stock position of Cochin area. The second question is

what route does these migrating specimens take, through deeper waters or along the inshore regions? The question arises because not a single tagged shrimp involved in this southerly migration was captured in the trawl fishery operating off Neendakara and Alleppey region located enroute, inspite of large scale publicity and propaganda including awards for recoveries in that region. The question also arises whether, like the recruitment by migration from Cochin taking place in south east coast, recruitment into the Cochin prawn ground takes place from northern regions of Kerala and Karnataka coasts. The answer to some of these questions may greatly change our application of the characteristics of the shrimp population in these waters. More elaborate mark recapture experiments will have to be executed and results obtained to get at solutions of some of these problems.

One important problem which could be studied by tagging and mark recapture experiments is to, arrive at mortality and recruitment parameters essential for understanding population dynamics in the proper sense. For this, intensive time-bound mark recovery experiments by tagging has to be conducted on selected sizes of particular species in a fishing ground, like for instance in the P. stylifera (Karikkady) fishery of Neendakara. Thousands of shrimps, should be tagged and released within a short span of time, and based on the recovery of these, the parameters can be statistically worked out reliably.

Now here the co-operation of the public at large and fishermen in particular is absolutely essential. Wide publicity through various media and communication about the experiments should be given in order to increase the awareness of people. Probably higher incentives should be given to the fishermen for return of the recovered specimens promptly. With all these it should be possible to solve some of the problems in the study of shrimp population dynamics.

7. EXPLOITATION OF SHRIMP FISHERY

Indigenous techniques

Fishing Crafts

A variety of indigenous crafts is used in shrimp fishing, from the simple catamarans of the east coast to the wellbuilt canoes of Maharashtra on the west coast. Motorised canoes and pablo boats and small and large sized trawlers are engaged in shrimp trawling. Ramamurthy & Muthu (1969) gave a detailed review of the fishing crafts and gears employed in the shrimp fishery of the country. Although the process of mechanisation of crafts has been in progress for the past several years, indigenous crafts like catamaran, canoes and plankbuilt boats are still operating in the traditional sector. According to 1980 census conducted by CMFRI there were 1,34,741 non-mechanised crafts in the country.

Catamarans: The catamarans are primitive type of crafts used on the surfbeaten coast, consisting of 3 to 5 logs of light wood tied together in a raft fashion. In different areas the size and number of the logs used vary slightly. Usually 2 to 4 men operate the craft.

Canoes: The dugout canoes are most common along the west coast, made by hollowing out a single log of wood and of varying sizes from 6 to 12 m length. Boat seines, shore seines, gill nets and cast nets are operated from these canoes, often with a crew of 4 to 8 men. Plank-built canoes, out-rigger canoes and flat-bottom canoes are also in use in different areas.

Plank-built boats: These are sturdy boats used in the northern part of both east and west coasts, used for bag net fishing. Manned by 7 to 12 men, these are considered most suited for mechanisation and quite a number of them has been already mechanised. The length ranges from 6.5. to 13.0 m.

Various types of plank-built boats have been indigenously evolved on the basis of their suitability for operations in the respective local conditions.

Fishing gears

As in the case of fishing crafts, a variety of indigenous gears are operated for capturing shrimps. Nearly 0.7 million gears of assorted types are operated in the country as per the 1980 census. Ramamurthy & Muthu (1969) reviewed the different types of gears in operation in shrimp fishing. According to the mode of operation the gears can be grouped under the following categories.

Fixed or stationery nets: These include the various types and sizes of bag nets and stake nets operated against the flow of the tide in both inshore and brackish water areas. The bag nets constitute the most important gears for shrimp fishing in Bombay and Gujarat coasts, where they are locally called 'Dol nets'. Depending on the manner in which these nets are operated there are two types, namely Khunt fishing and Sus fishing. The nets are conical in shape with a wide rectangular mouth. The size varies considerably, from 12 to 200 m in length, with cod end mesh size of 10 mm. There are different types of bag nets operated in West Bengal and Andhra Pradesh also, locally known as Behundi jal and Thoka valva respectively in these two areas. The fixed nets known as stake nets are in operation in the backwaters of west coast as well as east coast.

Seine nets. The seine nets include the seines with or without bags (and wings). They are known as boat seines or shore seines depending upon whether they are hauled from a boat or from the beach. One of the important gears operated by the indigenous craft along Kerala coast is the boat seine known as Thangu vala of various dimensions, usually operated by two dugout canoes with 6-10 men. Boat seines of different types and dimensions are in operation for catching shrimps in other areas also.

Although the shore seines are mostly used for catching inshore pelagic fishes, prawns are also caught in these nets. Shore seines of varying sizes are in use in all the areas of the coastline.

Cast nets or falling nets : These are very common and primitive gears used all along the coast and limited in their efficiency. They are operated by a single person very near the shore in the open sea as well as in the creaks and estuaries. The size of the net varies from 2.5 to 6.0 m in radius with webbing of mesh size 10 to 20 mm. The net is cast fully spread and as it closes traps the fishes and prawns in the water column below the net.

Scoop nets or skimming nets : These are employed exclusively in the creaks and backwaters and comprise of the hand net, push net and lift net. The Chinese dip nets of Kerala backwaters are a type of lift nets.

Drift nets : The drift nets are passive wall nets of selective nature, also called gill nets made of cotton, hemp or synthetic fibre. The gill nets are at present increasingly used in fishing larger sized shrimps from the sea in certain regions.

Trammel net: This is a type of gill net recently introduced in the fishery along Tamil Nadu coast from 1984 onwards. In the trammel net there are three layers the middle one having smaller mesh of 45 mm size and one upper and lower layer each with larger mesh of 400 mm size. The traditional gill net locally known in Tamil Nadu as "Ara Valai" is of uniform 45 mm mesh size. Unlike this net, the trammel net has at the bottom lead as weights at regular intervals of 15 cm so that the net gets buried to a depth of about at least 10 cm in the silt sand or muddy bottom of the fishing ground. The overall length and breadth of this three-layered net is 120

to 200 m and 2.5 to 3.0 m respectively. This net is locally called in Tamil Nadu as "Mani valai" or popularly "disco net". An unusual bumber catch of Indian white prawn Penaeus indicus from Kovalam bay near Madras was reported recently by operation of these nets (CMFRI, 1985). Incidentally, in the report of the Kalavar Commission submitted to the Government of Kerala in 1985 it is recommended that this type of trammel nets be introduced in specified numbers in the fishery of the various districts of the State.

Modern Technology - Shrimp trawling

Mechanised crafts

Motorisation of the indigenous crafts was the first step in the mechanisation of shrimp fishing. In due course many designs of small and medium sized mechanised boats to be operated from harbours and sheltered bays were introduced. The number of mechanised crafts currently in operation is nearly 19,000. Shrimp trawling is mostly carried out by the Dan boats (6.6 x 2.2 x 1.0 m), Pablo boats (7.4 x 2.1 x 1.05 m) and shrimp trawlers (9.6 x 3.0 x 1.2 m and above). The horse power of the smaller boats ranged from 10 to 60. The larger of these boats are partly or fully decked and with trawling winches. Larger steel trawlers fitted with 90-300 HP engines and refrigerated fish holds are operated by some of the big firms as well as the Exploratory Fisheries Projects of the Government. The larger trawlers number 75-100.

Trawl nets

With the increase in demand for shrimps for processing and export, along with the mechanisation of the fishery stern trawling, particularly for shrimps, was attempted even with small mechanised boats and met with unprecedented success. Consequent to the expansion of the shrimp industry in a big way this new fishing method has come to stay, although

indigenous crafts and gears are also being operated for catching shrimps to a certain extent.

Otter trawls are the most effective gears operated for shrimp fishing, the sizes of the trawl nets varying with the sizes of the crafts from which they are operated. Generally two or four seam trawl nets, overhang or non-overhang type with headline length of 7-27 m between the upper wing ends are used. Depending on the dimensions of the net and the towing power required the size and weight of the otter boards vary. The Indian Standards Institution has also brought out requisite standards for the stern trawling gears for the different class of vessels.

Several new designs of trawling gear were introduced during the last few years. Design of a 15.25 m four-seam trawl for operation from a 9.45 m trawler is very popular. In addition to these trawls, bulged belly trawls are also in use. A 15 m bulged belly trawl suitable for 10.97 m trawler is being increasingly used. Some of the larger trawlers are resorting to out-rigger trawling.

Catches, fishing effort and CPUE

Description of the fishery

A section of the shrimp fishery of the country continues with the traditional crafts and gears, while mechanisation is slowly replacing the indigenous sector in several areas. The major development in mechanisation of shrimp fishery took place in the fifties with the introduction of shrimp trawling and at present trawling is being increasingly practised in most of the areas. In addition some of the indigenous gears like the 'dhol nets' of Maharashtra and gill nets of other areas are operated by mechanised boats. Table 11 would indicate the extent of shrimps landed in the country by the

mechanised and non-mechanised sectors (average for the past 6 years).

Effect of effort on catch

The prawn catches and corresponding effort put in for their exploitation in the different States for the five years 1979 to 1983 are studied (Fig.2). It is seen from the data that the catch per unit effort fluctuated over the years without any specific trend in all the States except Andhra Pradesh and probably Orissa for which State sufficient data for all the five years is not available. From this it would appear that in these two States the effort could probably be increased to a certain extent, as the catch per unit effort increases as the effort increases.

8. OVERFISHING OF SHRIMPS

In general the total production of shrimps in the country has shown a decline from the highest levels reached in 1973 and 1975. However, as seen in the triennial average shown in Fig.1 the production is showing a tendency to increase in recent years. However, when some of the individual States are considered the regular declining tendency, probably due to overfishing is evident. Region-wise stock assessment only will show the exact position. Even in a State, analysis of the production and population data in different areas would be necessary in order to understand whether overfishing is taking place or not.

Levels of exploitation and maximum sustainable yield

For assessment of shrimp stocks in the fishing ground various analytical methods are used. By using one of the models based on law of diminishing returns, ie., in a heavily exploited stock the catch per unit effort(CPUE) generally decreases as the effort increases, making it possible to plot

the yield curve from which the maximum sustainable yield (MSY) could be determined, the MSY and the corresponding optimum effort of some of the important shrimp landing centres of the country have been worked out. These are given in table 12 along with the actual catch of the respective centres in 1980.

From the table it is clear that for the fisheries around Sasson dock in Bombay, Karwar, Mangalore, Calicut, Cochin, Neendakara, Mandapam and Madras the indication is that increasing the effort beyond the optimum value is not likely to increase the yield. In places like Kakinada and Waltair in Andhra Pradesh the level of fishing effort so far does not have any adverse effect on the yield and the effort in operations could be increased.

In Kerala State the decreasing trend in production of shrimps over the years in the fishery is very much evident in most of the important centres of shrimp fishing, especially at Neendakara, the most important centre for the shrimp trawling, as seen by the relationship between CPUE and effort. There is definite indication that increasing the effort beyond a particular level is not likely to increase the yield to any extent. At Neendakara from the peak fishing in 1973 and 1975 there has been considerable decrease in the total catch as well as catch per unit effort in the subsequent years, except in one or two years when there were slight increases. This tendency of decline in catch and CPUE is seen in most of the centres in the State and thus the decline is reflected in the total shrimp fishery of Kerala State. Although the general tendency of the decline in the shrimp catches is evident in the total prawn fishery of the country, no other maritime State is as badly affected by overfishing as Kerala.

One of the most important factors leading to the general decline in the shrimp fishery of particular States or the country as a whole appears to be the excessive effort on a resource which was in fact more limited than it was earlier thought to be. The coastal shrimp fishing grounds of the country is limited to at the most the 80 m depth zone. Indications available so far from exploratory and experimental fishing operation results are that beyond this depth zone very little exploitable shrimp resource exist except in some regions in very deep waters on the continental slope beyond the 200 m depth area, which is beyond the reach of the existing fishing fleet of smaller vessels. The zone upto the 80 m depth region is at the moment exploited to the maximum extent in some of the States like Kerala, by a combination of effort exerted by mechanised sector as well as traditional sector, except, perhaps, limited areas which are not accessible for the smaller mechanised vessels conducting single day operations. For all practical purposes the presently exploited level of shrimp fishery from the inshore coastal zone may be considered as almost at the saturation level with possible increases or decreases this way or that way depending on natural fluctuations caused by environmental features and other factors. The stock position, calculation of MSY at important centres, trend in yield curves and the recruitment studies all point to this fact that the resource available in the existing fishing grounds is limited to a particular level in several centres along the coastline and exploitation beyond this level will lead only to decline and overfishing. However, along the east coast in some States like Andhra Pradesh, Orissa and West Bengal there are possibilities of increasing the yield by further proper exploitation.

Closely allied to the fact of limitation of resources in the exploited grounds is the indiscriminate addition of mechanised vessels and power fishing into the fishery as a

causative factor for the depletion of the resources wherever it is noticed. Therefore the input of further effort into the fishery has to be viewed with a proper management approach.

Destructive effects of trawling and influence on certain species

As a result of the mode of operation in the trawl fishing the fact cannot be denied that an indiscriminate sweeping of the bottom of the sea in the fishing ground is taking place. This might result in the possible destruction of quite a lot of young ones of the fishes appearing as by catch in the nets. On an average in Kerala the by-catch includes trash fish and table fish of the demersal varieties, both young and adult amount to nearly 60 to 70% of the total catches and the rest only is contributed by shrimps. The percentage of by-catch in the trawl nets along other parts of the Indian coast is in fact, much more. In these by-catches there are wide variations in the constitution of the species belonging to several varieties both area-wise and season-wise. It is true that in some seasons in several of the areas large quantities of young ones of some of the costly demersal table fishes are being caught in the nets, resulting in wastage of the resources. Even in the case of shrimps also sometimes during the peak season of the fishery in places like Neendakara good quantities of undersized shrimps are caught, resulting in under utilisation of the resources. These are definitely some of the disadvantages of the indiscriminate fishing as a result of the trawl net operations and these also needs careful study for proper management of the fishery.

Analysis of the data of species composition in the trawl catches of shrimps for the past several years clearly indicate in the all India level the percentage representation of P.stylifera has increased and that M.dobsoni decreased the

former species taking the first place relegating the latter to a second place in the total abundance in recent years. This is a fact noticed in the shrimp fishery of most of the States of the west coast. However, both of the species are of the smaller variety of the exported prawns, so that this change of species do not in any way affect the export industry.

The impact of mesh size reduction of the trawl nets on the shrimp catches was studied by Sudhakara Rao et al (1980) in Kakinada shrimp fishery in Andhra Pradesh. From the analysis it is clear that the fishing with small mesh sized nets has resulted in a change in the species composition in the catches and also decrease in the sizes of the constituent species. The change in species composition is brought about by the appearance of large quantities of a small sized non penaeid shrimp of the genus Acetes which was not found in the catches of the nets of larger mesh sizes. This has naturally brought down the sizes of the shrimps caught. In addition a general reduction of the sizes of the conventional species also was noticed as a result of the fishing with nets of smaller mesh sizes. While mentioning these facts it may also be pointed out that the trawl net fishery has helped in locating new resources like that of Nemepterus japonicus along some areas of the coast, especially south west coast.

The problems connected with shrimp resource management revolves round (1) management of the resource at the earlier phase of the concerned species in relation to recruitment in and out of the brackish water systems and (2) proper management of the adult population in the fishing grounds in order to limit the exploitation at the optimum level of sustainable yield. As far as the earlier phase of the shrimp is concerned, a proper understanding of the breeding season, the migratory pattern particularly bathymetrical, recruitment to the brackish water region and growth pattern

of juveniles are necessary for a management approach to the maintenance of the resource in relation to the pre-fishing phase. As regards the resources in the fishing grounds, a close monitoring of the catch rates; catch per unit effort; sizes of the component species and their recruitment and mortality rates will be necessary. Depletion in shrimp stocks are probably indicated by (1) catch rate decrease regularly over the years, (2) reduction in the sizes of the shrimps, (3) imbalances in the sex ratios and so on. In a capital intensive fishery the fall in catch rate may result in economic over fishing. At the same time biologically the resources may be still a viable one capable of subsequent speedy recovery or even attaining stability of production over a number of years. In the case of shrimp resources in certain areas of the coastline of India there has been records of such decreasing trends in catch rate in the '60s and '70s and subsequent revival of the fishery (Table 9). In other words conservation in the biological sense was of minor importance, but exploitation for maximum economic return should be the consideration, so much so the problem of management is a socio-economic one. However, the bigger problem is that it is hence also "political".

9. MANAGEMENT MEASURES

The techniques for the management of a fishery would largely depend on the objectives which have to be properly defined before deciding on the measures to be taken.

There could be different views about the specific objectives in management as indicated by Silas et al (1984) One view is that it is difficult to manage shrimp fisheries in the biological sense but purely economic measures should motivate management so that the fishery could be based on orderly exploitation for maximum economic return. Another view point is that the aim should be maximum development of the resources and increase of production. Yet another management

motive is concerned with socio-economic aspect in which management aim should be to create maximum employment potential in the fishing sector. Shrimps are annual stocks with high natural mortality and because of this fact it would be advisable to fish hard except for giving protection to the nursery areas, partly to safeguard the young prawns and partly to protect their habitat. This would also indicate that the socio-economic factors were of far more importance than biological factors.

A close look at all these view points might only lead to the conclusion that a combination of all these should be the ideal objective in proper management approach in shrimp fishery. But it has to be admitted that it would be extremely difficult to evolve suitable management techniques with all these objectives put together. The management objectives with which the problems are approached in this country has been oriented towards higher production and maximum development of the resources.

Considering all these view points the following are some of the measures which could be adopted for p roper management of the shrimp fishery.

1) Closure of fishery: Enforcement of a temporary closure of the fishery is a method adopted in conservation. This can be either by (a) seasonal closures or (b) locational closures. In the first case as far as the shrimp fishery of the mechanised boats off the south west coast of India was concerned the south-west monsoon season acted almost as a closed season for the fishery, so that another closed season was not necessary. Naturally enough the stoppage of the fishery due to the south west monsoon takes place at a time when the mean sizes of all the species in the fishery are at the lowest. The absence of fishing operations for two or three months at that time acted as a natural conservation measure. But in

But in recent years fishing operations are being carried out during these monsoon months in several centres. For example at Neendakara the maximum fishing operations are carried out during the south-west monsoon period. In fact the maximum landings of shrimps at this centre during the last several years were in this period. So in such places some season for closure of the fishery for the purpose of conservation of the resources could be thought of. In locational closures the approach is to close one particular locality or fishing ground for a certain period based on the data available.

2) Mesh regulation: Regulation of mesh sizes of the gears used in the fishery is another important method used in conservation of fishery resources. However, in the case of the shrimp fishery, being a multispecies fishery constituted by species growing to different sizes, a catch of small or medium sized shrimps would include smaller sized but adult specimens of the species growing to smaller sizes as well as the smaller sizes of groups of species growing to medium or larger sizes. Hence limitations of mesh size at a higher level with a view to catch only the larger sizes would lead to prevention of capturing the adults of the smaller growing varieties which would thus be lost to the fishery. Thus mesh regulation at larger sizes will not be helpful in Indian shrimp fishery of the inshore regions. But in the estuarine fishery involving smaller sizes of shrimps only, limiting the mesh size at larger dimensions may help in sparing the very small shrimps being subjected to the fishery.

3) Limitation of fishing effort : When the available shrimp resources in the fishing grounds is subjected to increasing exploitation by introduction of more and more of effort, a stage would be reached when further input of effort results in uneconomic returns. In such cases it would

be helpful if some limitations is enforced in additional input of effort which may be achieved by licence limitation or any other governmental control, aiming at optimum efficiency for individual fishing unit. Its implementation would require biological, sociological, economic and political value judgements.

4) Catch restrictions : Limiting the catch per boat from a particular area or enforcing a quota system for catch per boat may also be used as a conservation measure. Enforcing catch quota or restricted hours of fishing for the boats in operation aim at restricting the total catch to an optimum level.

5) Diversification : Where the existing fishery is predominantly trawl fishery for shrimp, diversified fishery during certain seasons may be suggested for tapping other resources. In such cases adequate incentives and subsidies may be provided to help the diversification process.

6) Protection of brackishwater nursery grounds: In view of the inseparable link between the marine shrimp of commercial importance and brackish water environments in as much as these environments are used as the nursery grounds, is any conservation measure concerning the marine shrimp resources the protection of these nursery areas would have to be considered. Complete prohibition of shrimp fishing in these environments as practised in some countries of the world would be ideal. This being almost impracticable under the present circumstances, alternate methods of protection of the young ones in these environments have to be thought of. Closing the areas for shrimp fishing during certain seasons, mesh size regulation of the various gears in use in the fishery, limiting the unrestricted operation of fixed gear and such other small mesh nets or even phasing out the operation of

these gears, total ban of export of count sizes of shrimps below a fixed minimum level etc. are some of the methods for consideration in the protection of the nursery.

After properly studying the particular situation in different areas and centres of shrimp fishery any one of these methods or combination of these measures may be adopted for implementation in each area.

Protection of artisanal fishermen

The policy of the Government in the Centre as well as in the States for the development of the fisheries has been that of rapid mechanisation and modernisation of the fishery especially in view of the great demand for shrimps as a foreign exchange earner for the country. As a result of this policy introduction of mechanised vessels in large numbers has taken place in all the maritime states. Unfortunately this rapid mechanisation has not in any way benefited the artisanal fishermen. Side by side with the introduction of additional mechanised vessels in the inshore fishery the traditional sector also has been increasing with the addition of more traditional crafts and gears. Consequently now a situation has been reached where both the mechanised sector and the traditional sector are operating in the inshore fishing grounds supporting the fishery, resulting in depletionary tendencies in some areas and also open conflicts between the two sectors.

According to the census conducted by CMFRI in 1980 the total number of mechanised vessels in the country is about 19,000. The total number of non-mechanised crafts has reached above 1.5 lakhs and the number of indigenous fishing gears above 7 lakhs according to the same census. This phenomenal increase in the traditional sector would indicate that in the face of decreasing catches and catch rates this sector needs special consideration in the management of the fishery. The

only proper management solution for the fishery seems to be limiting the areas of fishing grounds for particular fishery and also, limiting the effort. Ultimately, if such methods also do not serve to solve the problems of protection of the artisanal fishermen, total banning of trawl fishery in limited areas may have to be resorted to, as has been carried out in Indonesia.

10. POTENTIAL RESOURCES OF SHRIMPS FROM THE DEEPER WATERS OF INDIAN COAST

In the light of the depletionary tendencies noticed in the inshore shrimp fishery of India, exploitation of alternate resources from deeper waters has to be seriously taken up. Shrimp resources have been located in the 81-450 m depth zone on the outer half of the continental shelf, shelf edge and the upper continental slope in some regions of the coast of India. The exploratory surveys carried out during 1965-79 have indicated the existence of commercially exploitable prawns, particularly in certain areas of the south-west and south-east coasts. Besides prawns, lobsters and crabs are also available on commercial concentration in the region. An area of about 5000 sq.km. lying between Ponnani and Quilon on the west coast* have been charted out by these vessels to be suitable for trawling and productive for the crustaceans especially at depths between 150 and 375 m in the former and 180 and 360 m in the latter region. Of this, the area lying between Quilon and Alleppey, which is generally referred to as "Quilon Bank" is the most extensive bathymatrically (3300 sq.km) and harbours maximum concentration of the crustacean resources. Other areas covered on the south-west coast are relatively narrow and the crustacean catch is also found to be such less than in the "Quilon Bank". In the Gulf of Manner, the deep sea trawling ground is a narrow belt lying between 25 and 40 km away from the coastline. In the recent surveys, extensions of these

* and 725 sq.km. in Gulf of Manner on the east coast

grounds to the north-west and upper east coast are also indicated.

The deep-sea prawn resource in the south-west and lower east coasts is mainly constituted by 5 species of pandalids namely, Heterocarpus woodmasoni, H.gibbosus, Parapandalus spinnipes, Plesionika martia and P.ensis and 6 species of penaeids namely, Aristeus semidentatus, Solenocera hextil Hymenopenaeus aequalis, Parapenaeus investigatoris, Panaeopsis rectacuta and Metapenaeopsis andamanensis. Of these, A semidentatus, S.hextii and H.gibbosus are larger species attaining the size ranging from 140 to 185 mm total length and they contribute to an average of about 18% of the shrimp catch. Majority of the other species belong to the size group 100-140 mm. The production of prawns in general is relatively greater between 275 and 375 m depth and the average catch rate works out to 89.43 kg/hr of trawling in the south-west coast. In the Gulf of Mannar, the prawn catch is negligible being less than 1 kg/hr of trawling.

Besides prawns, these grounds also sustain a lobster resource constituted by a single species, namely, Puerulus sewelli, wnich grows to a size of about 190 mm total length. Although this species occurs all along the areas surveyed, commercial concentration has been located in the "Quilon Bank", off Ponnani and Colachel on the South-west coast, and off Mandapam in Gulf of Mannar in the lower east coasts. The maximum density of the lobster is found to be between 170 mm and 270 m depth, yielding an average catch rate of about 107-174 kg/hr in the "Quilon Bank" and 207 kg/hr off Mandapam.

However, larger trawlers, capable of remaining out at sea for several days and equipped with expensive infrastructural facilities would be necessary for the exploitation of these deep water resources.

REFERENCES

ALAGARAJA.K.,M.J.GEORGE K.N.KURUP & C.SUSEELAN — 1986 — Yield-per recruit analyses on Parapenaeopsis stylifera and Metapenaeus dobsoni from Kerala State, India. J.Appl. Ichthyol. 2 (1986):1-11

ANTONY RAJA,B.T. — 1974 — Our pelagic fishery resources - present and potential harvest. Seafood Exp. Jour., 6 (1): 79-85

BHIMACHAR,B.S. — 1965 — Life history and behaviour of Indian prawns. Fish. Tech., 2 (1) : 1-11

CUSHING, D.H. — 1971 — Survey of resources in the India Ocean and Indonesian area. IOFC|DEV/71/2, FAO, Rome: 1-123

DEVERAJAN,K,J.SUNNY NAYAGAM,N.SELVARAJ, & N.N.PILLAI — 1978 — Larval development - Penaeus semisulcatus De Haan. CMFRI Bulletin 28:22-29

GEORGE,M.J. — 1959 — Notes on the bionomics of the prawn Metapenaeus monoceros Fabricius. Indian J. Fish. 5 (2):268-279

GEORGE,M.J. — 1974 — The food of the shrimp Metapenaeus monoceros (Fabricius) caught from the backwaters. Indian J.Fish. 21 (2):495-500

GEORGE, M.J. — 1975 — Observations on the growth in certain penaeid prawns studied in prawn culture experiments in paddy field Bull.Dept.Mar.Sci.Univ. Cochin.7 (1):41-55

GEORGE,M.J.& S.C.GOSWAMI — 1977 — Occurrence of larvae of commercial important penaeid prawns along the central west coast of India. Mahasagar 10 (3 & 4):129-137

GEORGE P.C.,B.T. ANTONY RAJA & K.C.GEORGE — 1977 — Fishery resources of the Indian Economic Zone. Souvenir Integrated Fisheries Project Oct.1977 : 73-116

GULLAND,J.A.Ed. 1971 The fish resources of the Ocean. Fishing News(Books) Ltd., England: 1-255

GULLAND,J.A. & B.J. ROTHSCHILD. Ed. 1984 Penaeid shrimps - Their biology and management. Fishin News (Books) Ltd, England: 1-308

JAMES,P.S.B.R.,K. ALAGARSWAMY,K.V.N. RAO, M.S.MUTHU,M.S.RAJA GOPALAN, K.ALAGARAJA & C.MUKUNDAN 1986 Potential marine fishery resources of India. Seminar of Potential Marine Fishery Resources, Cochin,CMFRI,ICAR 1-20 (Mimeo.)

JONES,S. & S.K.BANERJI 1968 A review of the Living Resources of the Central Indian Ocean. Proc.symp. Living Resources of the Seas around India. CMFRI publication : 1-17

KABANOVA YU,G. 1961 Primary production and nutrients in the Indian Ocean. Acad. des Sci. de DURSS Comite de l'Annee. 4 :72-75 (In Russian)

LING,S.W. 1962 Studies on the rearing of larvae and juveniles and culturing adults of Macrobrachium rosenbergii (de Man). Indo-Pacific Fish.Coun.Curr. Affairs Bull., 35:1-11

KUNJU,M.M 1968 Some aspects of the biology of Solenocera indica Nataraj. FAO Fish. Rep.(57) Vol. 2: 467-486

KURUP,N.S. & P.V.RAO 1974 Population characteristics and exploitation of important marine prawns of Ambalapuzha, Kerala.Indian J.Fish 21 (1):183-210

LALITHADEVI,S. 1986 Growth and population dynamics of the Indian white prawn Penaeus indicus H. Milne Edwards from Kakinada. Proc. Indian Acad.Sci 95 (5): 629-639

MENON,M.K. 1952 The life history and bionomics of the Indian penaeid prawn Metapenaeus dobsoni Miers. Proc. Indo-Pac. Fish. Coun.3: 80-93

MFIS,CMFRI 1982 New light on the migration of the Indian white prawn.Mar. Fish. Infor.Serv. T & E Ser. 45: 1-9

MFIS,CMFRI 1982 Prawns in purse seine catches. Mar.Fish.Infor.Serv. T & E Ser 42 : 9-13

MFIS,CMFRI 1985 The prawn fishery of the South Kanara coast with emphasis on the unusual catches of Metapenaeus dobsoni by purse seines and trawls during first half of September. Mar.Fish.Infor.Serv. T & E Ser. 65:1-7

MOHAMED,K.H. 1967 Penaeid prawns in the commercial shrimp fisheries of Bombay with notes on species and size fluctuations. Proc.Symp.Crustacea Mar.Biol.Ass.India IV: 1408-1418

MOHAMED,K .H.,M.S. MUTHU,N.N.PILLAI & K.V.GEORGE 1978 Larval development - Metapenaeus monoceros CMFRI Bulletin 28:50-59

MUTHU.M.S.,N.N.PILLAI & K.V.GEORGE 1978 Larval developments. CMFRI Bulletin 28: 12-21, 30-49 and 65-85

NAIR, P.V.R.,S.SAMUEL, K.J.JOSEPH & V.K. BALACHANDRAN 1973 Primary production and potential fishery resources in the seas around India. Proc. Symp.Living Resources Seas around India. CMFRI Publ, :184-198

PRASAD,R.R. 1966 Some aspects of productivity and fisheries of the west coast of India. Seafood Trade Jour. 1(8):11-15

PRASAD,R.R.,S.K. BANERJI & P.V.R.NAIR 1970 A quantitative assessment of the potential fishery resources of the Indian Ocean and adjacent seas. Indian J.Anim. Sci., 41(1):73-98

PRASAD,R.R. & P.V.R. NAIR 1971 Indian and the Indian Ocean fisheries. J.Mar.Biol.Ass. India. 15 (1):1-19

PILLAI,N.N. 1973 Seed production. In breeding and rearing of marine prawns. CMFRI Spl.Publ. 3:75-80

RAJE,C.P & R.R. RANADE 1972 Larval developments of Indian penaeid shrimps I & II.J.Indian Fish.Ass. 2(1&2):1-16 & 30-46

RAJYALAKSHMI,T. 1961 Observations on the biology and fishery of Metapenaeus brevicornis(H.M.Edwards) in the Hooghly estuarine system. Indian J.Fish 8 (2):383-403

RAMAMURTHY.S. & M.S.MUTHU 1969 Prawn fishing methods. In Prawn Fisheries of India. CMFRI Bulletin. 14:235-257

RAO,P.VEDAVYASA 1968 Maturation and spawning of the penaeid prawns of the south west coast of India. FAO Fish Rep. (57) Vol.2: 285-302

RAO,P. VEDAVYASA 1973 Studies on the larval development of the commercially important prawns of India. J.Mar.biol.Ass.India.15(1) :95-124

RAO. G.S. 1978 Larval development of Metapenaeus brevicornis (H.M.Edwards) CMFRI Bulletin 28 :60-64

SILAS,E.G.,M.J.GEORGE & T.JACOB 1984 A review of shrimp fisheries of India: A scientific basis for the management of the resources: In Penaeid shrimps: their biology and management. Fishing News (Books) Ltd., 83-103

SUDHAKARA RAO,G., C.SUSEELAN & S.LALITHADEVI 1980 Impact of mesh size reduction of trawl nets on the prawn fishery of Kakinada in Andhra Pradesh.Mar.Fish.Infor.Serv. T & E Ser.21:1-6

THOMAS,M.M.,M.KATHIRVEL & N.N.PILLAI 1974 Spawning and rearing of penaeid prawns Metapenaeus affinis and Metapenaeus dobsoni under laboratory conditions. Indian J.Fish. 21 (2): 543-556 & 575-579

SILAS,E.G.,M.S.MUTHU, N.N.PILLAI & K.V.GEORGE 1978 Larval development of Penaeus monodon Fabricius CMFRI Bulletin, 28:2-12

UNAR,M. & N.NAAMIN 1984 A review of the Indonesian shrimp fisheries and their management: In Penaeid shrimps - their biology and management. Fishing News (Books) Ltd., :104-110

YE CHANG CHENG 1984 The prawn (Penaeus orientalis Kishinouye) in Pohai Sea and their fishery: In Penaeid shrimps - their biology and management. Fishing News (Books) Ltd.,:49-60

ZELINGE VAN,N.P. 1984 The shrimp fisheries in the Gulf between Iran and the Arabian Peninsula: In Penaeid shrimps - their biology and management. Fishing News (Books) Ltd., 71-83.

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Table 1. Productivity data for Indian Ocean region based on Kabanova (1968) and Cushing (1971)

North east monsoon (December-April)	South west monsoon (July-September)
High values above 1.45 $g^C/m^2/day$	
Visakhapatnam, head of Bay of Bengal, Rangoon and Java Sea, around Andaman Islands and right across the northern Arabian coast.	Off Saudi Arabia entire western Arabian Sea, off South west coast of India and Sri Lanka, Northern Bay of Bengal, Central Bay and Java Sea.
Values between 0.38-1.45 $g^C/m^2/day$	
East coast of India including Sri Lanka, whole of the Andaman and Java Seas, a patch along western equitorial region and the Bay of Bengal.	Central Arabian Sea with extension into the south western Indian Ocean and the whole of Bay of Bengal.
Low values 0.38 $g^C/m^2/day$	
Central parts of the Arabian Sea, Bay of Bengal and most of the southern Indian Ocean	Central portion of the southern Indian Ocean.

Table 2. Annual potential yields from Asian Countries of the Indian Ocean region (in 1000 tonnes)

Area	Demersal (including shrimps)	Pelagic	Total
Saudi Arabia, Muscat Oman etc.	100	650	750
Pakistan	160	90	250
India (west coast)	580	1,020	1,600
Maldives, Lakshadweep	7	23	30
Red sea	125	25	150
Persian Gulf	55	40	95
India (east coast)	143	672	815
Bangladesh	98	250	348
Burma	326	400	726
Thailand (West coast)	58	20	78
Malaysia (West coast)	600	100	700
Sri Lanka	52	90	142
Andaman & Nicobar	4	8	12
Indonesia	90	260	350
Oceanic (Tuna)	-	450	450
Total	2,398	4,098	6,496

Table 3. Present yield (average for 1980-84) and estimated potential yield of marine fishes in the EEZ of India (in 1000 tonnes)

Region	Present production	Annual potential yield			Total
		Depth 0-50 m	50-200 m	Beyond 200 m	
North west	489	540	340	-	880
South west	498	700	720	-	1,420
South east	386	480	200	-	680
North east	65	540	200	-	740
Lakshadweep	4	-	90	-	90
Andaman & Nicobar	4	-	160	-	160
Oceanic of all regions	-	-	-	500	500
Total	1,446	2,260	1,710	500	4,470

Table 4. Groupwise present yield (average for 1980-84) and estimated potential yield of marine fishes in the EEZ of India (in thousand tonnes)

Groups	Present production	Potential yield
Pelagic fishes	714	1,850
Demersal fishes	336	1,096
Crustaceans	214	325
Cephalopods	15	180
Miscellaneous	164	520
Oceanic fishes	3	500
Total	1,446	4,470

Table 5. Total world production (in tonnes) of fish, crustaceans etc. and production in Asian countries, both inland and marine during 1977-1985

	1977	1978	1979	1980	1981
World	68224600	70154700	71060400	72008300	7477100
Total	7124200	7056800	7264600	7625000	8146400
Asia	4133700	4170200	4349600	4672900	5142100
Crustacean	108700	117500	119600	126700	129900
Total	61100400	63097900	63795800	64383300	66630700
Asia	26739100	25969700	25587300	26260900	27128200
Crustacean	2653200	2782400	2919100	3124500	3056400

Source: Yearbook of fishery statistics - 1983 & 1985 - Catches and landings. FAO fisheries Sereies, Vol 56, 1984 and Vol 60, 1987.

Table 5 (Page 2)

Total world production (in tonnes) of fish, crustaceans etc. and production in in Asian countries, both inland and marine during 1977 -1985

	1982	1983	1984	1985
World	76464200	76470600	83096000	84945300
Total	8431200	8859300	9493000	10120100
Asia	5297000	5747300	6084500	6748500
Crustacean	147000	157900	169000	185300
Total	68033000	67611300	73603000	74825200
Asia	27787200	29008100	30626400	30544000
Crustacean	3238100	3034500	3033200	3234100

Table 6. Total fish production in Asian countries during the years 1977 to 1985 (in tonnes)

	1977	1978	1979	1980	1981
Near East Asia	524642	594213	726055	820659	834818
Afghanistan	1500	1500	1500	1500	1500
Bahrain	4837	4000	4313	5502	6098
Cyprus	1220	1276	1314	1336	1462
Gaza strip	4525	4700	1913	972	1139
Iran LR	69750	67276	65444	43704	44757
Iraq	26101	26100	55228	53245	26219
Israel	24400	25600	26630	25718	25238
Jordan	31	36	36	56	35
Kuwait	5252	6313	2764	3091	3398
Lebanon	1700	1800	1750	1800	1600
Neutral Zone	-	-	-	-	-
Oman	7000	73000	76000	79000	83650
Qatar	2433	2200	2200	2178	2604
Saudi Arabia	23400	26550	26160	26425	26425
Syria	3537	3639	3749	3911	3777
Turkey	164470	244125	349684	426855	470180
United Arab EM	64400	64000	64000	64000	68000
Yemen Ar Rep.	17500	19250	18000	17000	16000
Yemen Dem.	63986	48055	51600	89684	17974

Table.6 Page.2

Total fish production in Asian countries during the years 1977 to 1985 (in tonnes)

	1982	1983	1984	1985
Near East Asia	864894	945158	991953	100846
Afghanistan	1500	1500	1500	1500
Bahrain	6577	6751	5599	7763
Cyprus	1602	2058	2261	2134
Gaza strip	1179	798	1553	1553
Iran LR	39736	34500	58139	60351
Iraq	26219	26219	21000	21500
Israel	23679	22402	22953	20959
Jordan	19	17	20	22
Kuwait	4497	4090	4568	5234
Lebanon	1500	1400	1300	1500
Neutral Zone	-	-	-	-
Oman	89376	108766	105000	101180
Qatar	2331	2144	3173	2484
Saudi Arabia	26425	26425	40000	43696
Syria	3777	3777	5342	5000
Turkey	506350	567304	566933	576069
United Arab EM	70075	73115	73115	72380
Yemen Ar Rep.	14000	12200	18323	20598
Yemen Dem.	69731	74124	84127	85200

contd.....

Table 6. contd..

	1977	1978	1979	1980	1981
Southern Asia	3391870	3430835	3484372	3596265	3695032
Bangala Desh	643000	645000	646000	650000	686625
Bhutan	1000	1000	1000	1000	1000
India	2311869	2306139	2839528	2442242	2443974
Maldives	26300	25800	27700	34600	34900
Nepal	3000	3300	3500	3654	3868
Pakistan	267954	293029	300390	279263	317849
Sri Lanka	138747	156567	156567	185506	206816
East & Southeast Asia	9532313	9632205	9739554	9762690	10470937
Brunei	2195	2704	2792	2161	2312
Burma	518700	540500	564070	580010	594540
East Timor	0	0	0	0	0
Hong Kong	158269	162495	189782	194551	182327
Indonesia	1567784	1642043	1742452	1841814	1903258
Korea Rep.	2085426	2091921	2162889	2091134	2365990
Laos	20000	20000	20000	20000	20000
Macau	4337	6666	6278	6624	7545
Malaysia	619295	685107	696329	736486	804094
Phillippines	1508705	1494580	1475196	1556602	1686636
Singapore	15105	16172	16932	16044	16112
Thailand	2188492	2099281	1946334	1792948	1989025

Table 6. contd.. (Page 2)

	1982	1983	1984	1985
Southern Asia	3649850	3855481	4203595	4211343
Bangala Desh	724800	728500	754000	763731
Bhutan	1000	1000	1000	1000
India	2335151	2520000	2854813	2810000
Maldives	30300	38500	47443	43723
Nepal	4400	2112	4860	9076
Pakistan	337289	343402	372264	408404
Sri Lanka	216910	221967	169215	175409
East & Southeast Asia	10594627	11094835	11064160	11260820
Brunei	2307	3105	2226	2986
Burma	584410	585800	609740	643750
East Timor	0	0	0	0
Hong Kong	180981	188798	199672	198196
Indonesia	1999061	2112230	1992535	2067090
Korea Rep.	2280821	2400387	2477080	2649880
Laos	20000	20000	20000	20000
Macau	6456	7000	11800	12400
Malaysia	682509	741089	664967	632185
Phillippines	1787744	1836877	1935399	1867701
Singapore	19346	19549	25468	23032
Thailand	2120133	2250000	2134846	2123600

Table 6. Contd..

	1977	1978	1979	1980	1981
Other NEI A	844037	870736	916400	924316	899098
Japan	10123359	10179006	9945516	10427920	10675952
China	4463250	4393643	4054295	4235348	4377000
Other Asian	1862965	1884394	1960537	2065137	2191237
Kampuchea Dm	84700	40900	30000	51600	68700
Korea DP Rp	1190000	1260000	1330000	1400000	1500000
Mangolia	265	494	537	537	537
Viet Nam	588000	583000	600000	613000	622000

Table 6 contd..... (page.2)

	1982	1983	1984	1985
Other NEI A	910799	930000	990427	1020000
Japan	10775265	11250000	12021074	11443702
China	4926683	5213261	5926793	6778819
Other Asian	2249187	2374287	2480366	2568370
Kampuchea Dm	58650	63750	65000	68000
Korea DP Rp	1550000	1600000	1650000	1700000
Mangolia	537	537	366	370
Viet Nam	640000	710000	765000	800000

Table 7. Total shrimp production (in tonnes) in Asian countries during 1980 to 1985 (inland & marine)

	1980	1981	1982	1983	1984	1985
Near East Asia						
Bahrain	700	503	727	834	808	1325
Gaza strip	25	24	11	7	2	2
Iran IR	1931	2000	2000	2000	4000	4800
Israel	74	65	60	135	95	100
Kuwait	305	286	338	596	672	960
Qatar	500	500	430	68	2	33
Saudi Arabia	1650	1650	1650	1650	1700	1858
Turkey	588	999	1211	4776	6212	7517
United Arab Em.	-	240	320	399	399	120
Yemen AR RP	280	260	230	-	365	389
Southern Asia						
India	250314	164165	199211	214980	202967	198050
Pakistan	25895	30000	26542	27502	27543	26685
East & Southeast Asia						
Brunai	497	427	559	496	585	535
Hong Kong	13594	11980	11131	9661	11751	13681
Indonesia	234463	159401	129176	134491	99752	105230
Korea Rep	23580	25718	34575	37524	31862	40351
Malaysia	83831	94487	67428	76475	70136	69004
Phillippines	25773	36807	44565	55748	52237	62399
Sri Lanka	4950	7130	9939	10222	-	-
Singapore	1112	1193	1489	1667	2179	1925
Thailand	133311	148266	137460	173987	136432	153111
Other NEI a	30594	73259	80429	82124	100686	103673
Other Asian						
Kampuchia Dm	260	220	200	190	200	200
Viet Nam	42100	41500	42800	49100	53000	55400
Japan	50986	54652	58369	60866	62561	54625
China	166102	134011	176956	185790	207085	229150

Table 3. Marine shrimp landings of India (in tonnes) from from 1959 to 1935

Year	Penaeid prawns	Nonpenaeid prawns	Total
1959	27,632	37,805	65,437
1960	31,759	36,271	68,030
1961	39,083	23,635	62,768
1962	43,251	34,984	33,235
1963	41,071	40,522	81,593
1964	63,389	31,506	94,395
1965	38,085	41,415	79,500
1966	56,146	34,768	90,500
1967	63,310	31,112	94,422
1968	69,514	31,922	1,01,436
1969	72,133	33,965	1,06,098
1970	89,357	31,834	1,21,691
1971	72,109	76,734	1,48,343
1972	78,361	85,488	1,63,849
1973	1,36,514	66,955	2,03,469
1974	1,14,934	55,244	1,70,178
1975	1,41,713	79,038	2,20,750
1976	1,14,640	76,787	1,91,427
1977	96,472	73,992	1,70,464
1978	1,29,204	50,652	1,79,856
1979	1,13,665	63,917	1,77,582
1980	1,12,037	58,700	1,70,737
1981	83,539	61,430	1,44,969
1982	1,10,797	51,143	1,61,945
1983	1,18,140	48,737	1,66,877
1984	1,30,051	61,961	1,92,012
1985	1,21,141	67,070	1,88,211

Table 9. Total shrimp landings statewise from 1969 to 1984

Maritime States	1969	1970	1971	1972	1973	1974	1975
West Bengal & Orissa	5,638	3,016	1,500	1,471	3,051	3,487	5,707
Andhra Pradesh	6,064	6,890	9,205	5,582	8,839	12,699	10,675
Tamil Nadu	5,814	5,264	3,699	5,033	5,789	8,106	12,033
Pondicherry	614	447	290	182	41	29	64
Andamans	8	10	12	12	8	28	28
Total east coast	18,138	15,627	14,706	12,280	17,728	24,349	28,507
Kerala	34,368	36,954	32,813	36,577	85,751	60,829	77,962
Karnataka	3,980	7,539	4,420	8,075	8,236	12,696	3,074
Goa	559	627	279	561	785	1,448	1,762
Maharashtra	45,780	57,345	93,611	1,04,125	80,349	64,737	93,665
Gujarat	3,273	3,599	3,014	2,231	10,620	6,119	15,781
Total west coast	87,960	1,06,064	1,34,137	1,51,569	1,85,741	1,45,829	1,92,244
All India total	1,06,098	1,21,691	1,48,843	1,63,849	2,03,469	1,70,178	2,20,751

contd.....

Table 9. contd.....

Total shrimp landings statewise from 1969 to 1981

Maritime States	1976	1977	1978	1979	1980
West Bengal & Orissa	5,635	1,690	3,879	3,588	1,304
Andhra Pradesh	11,108	11,375	9,563	11,814	10,006
Tamil Nadu	9,033	8,356	13,912	11,119	10,028
Pondicherry	93	105	316	604	527
Andaman	39	45	265	64	54
Total east coast	25,908	21,571	27,935	27,189	21,919
Kerala	34,533	40,324	45,428	29,597	54,375
Karnataka	2,594	3,335	8,440	4,660	3,226
Goa	4,643	1,460	1,673	1,594	1,853
Maharashtra	1,04,474	93,653	85,346	1,01,846	70,742
Gujarat	19,275	10,121	11,034	11,953	18,590
Total west coast	1,65,519	1,48,893	1,51,921	1,49,650	1,48,786
All India total	1,91,427	1,70,464	1,79,856	1,76,839	1,70,705

Table 9. contd.... (page.2)

Total shrimp landings statewise from 1969 to 1981

Maritime States	1981	1982	1983	1984
West Bengal &	1,495	1,183	2,109	13,039
Orissa	1,383	2,318	2,018	2,069
Andhra Pradesh	8,335	14,529	16,418	9,970
Tamil Nadu	14,252	14,462	13,711	16,607
Pondicherry	389	320	301	917
Andaman	26	63	..	201
Total east coast	25,880	32,875	34,557	42,803
Kerala	22,428	26,773	29,857	36,267
Karnataka	4,126	7,698	7,882	5,511
Goa	2,237	3,491	7,744	4,853
Maharashtra	74,571	74,723	63,161	83,164
Gujarat	15,727	16,385	13,616	19,384
Total west coast	1,19,089	1,29,070	1,32,260	1,49,179
All India total	1,44,969	1,61,945	1,66,817	1,91,982

Table 10. Species representation and their percentages in shrimp landings of India in 1980 and 1981

Species	1980		1981	
	All India landings in tonnes	%	All India landings in tonnes	%
Solenocera crassicornis	6,388.5	3.7	8,084.0	5.6
Penaeus indicus	10,298.2	6.0	7,537.0	5.2
P. merguiensis	495.9	0.3	1,096.0	0.8
P. monodon	2,655.8	1.6	941.0	0.6
P. semisulcatus	1,712.5	1.0	7,893.0	5.4
P. penicillatus	932.8	0.6	..	..
Metapenaeopsis stridulans	..	..	506.0	0.3
Metapenaeus dobsoni	18,998.1	11.1	10,059.0	6.9
M. affinis	7,231.7	4.2	5,025.0	3.5
M. monoceros	5,607.9	3.3	7,073.0	4.9
M. brevicornis	835.7	0.5	907.0	0.6
M. kutchensis	1,534.9	0.9	857.0	0.6
Parapenaeopsis stylifera	50,829.0	29.8	29,109.0	20.1
P. hardwickii	2,214.0	1.3	2,123.0	1.5
Acetes indicus	41,282.4	24.2	38,430.0	26.5
Nematopalaemon tenuipes	12,653.7	7.4	19,698.0	13.6
Exopalaemon styliferus	1,276.9	0.7	859.0	0.6
Exhippolysmata ensirostris	3,091.5	1.8	2,309.0	1.6
Other species	2,697.5	1.6	2,458.0	1.7
Total	1,70,737.0	100.0	1,44,969.0	100.0

Table 11. Statewise average catches (1974-79) of shrimps by mechanised and non-mechanised sectors.

State	Shrimp catch mechanised	Shrimp catch non-mechanised
Orissa	2,544	458
Andhra Pradesh	5,357	6,300
Tamil Nadu	9,109	4,000
Kerala	26,814	2,800
Karnataka	4,633	2,200
*Maharashtra	100,000	9,600
Gujarat	4,600	6,400
Total	153,057	31,758

*Nearly 75% of the shrimp catch of the State consists of non-penaeid variety.

Table 12. Estimated MSY and the corresponding effort relating to prawns for areas around important landing centres in India

Centres	MSY (tonnes)	Optimum effort (boat days)	Catch in 1980 (tonnes)
Sasson Dock (Bombay)	2,890	39,841	3,914
Karwar	538	10,665	557
Mangalore	1,715	30,498	980
Calicut	760	18,672	355
Cochin	4,426	48,690	3,516
**Neendakara	53,487	4,65,912	36,568
Mandapam	363	23,756	-
Madras	921	93,979	-
Kakinada	*	*	2,580
Waltair	*	*	625

* CPUE increased with increase in f and MSY was not worked out.

** According to a recent study by Alagaraja et. al (1986 the MSY figure for Neendakara for P.stylifera is only 25,000 tonnes.

APPENDIX 1

5. BIOLOGY OF SHRIMP FISHERY OF INDIA

Brief reviews on the biology, bionomics and fishery of the important species represented in the commercial fishery of India, documented in various publications are appended below:

1. PENAEUS INDICUS H. Milne Edwards

Distribution

General distribution, ranging from the coasts of India and Sri Lanka to the West through the Gulf of Aden to Madagascar and east coast of Africa, and to the East through Malaysia and Indonesia to Philippines, New Guinea and Northern Australia. In India it occurs in the commercial catches along the entire coast upto 80 m depth zone.

Distribution at different stages of life history

Eggs

Eggs of P.indicus have been reported to occur in large numbers in sub-surface plankton in Madras waters from 3 m depth below surface. In Cochin waters, the species is noted to prefer deeper waters for spawning, eggs and early larvae having been seldom obtained along with those of other penaeid shrimps known to exist in the same area.

Larvae

Large numbers of larval forms in advanced stages are present in the inshore surface waters in Cochin and other areas where the species occurs in the fishery. These larvae are also recorded in other regions of the west coast like for instance in Goa waters in plenty.

Post larvae

Post larval stages of the species (8 to 14 mm in total length) are represented in the plankton collections taken from the estuaries and also from the surf region. At Cochin large numbers of post larvae for using as seed for the culture of the species in paddy fields could be collected from the surf region as well as from the canals adjoining the backwaters. The distribution of the post larvae of the species in Mangalore, Karwar and Goa waters also have been studied by several authors.

Juveniles

Juvenile stages (30 mm to 120 mm) spend their life mostly in the estuaries and backwaters and here they support a good commercial fishery. After attaining sizes up to 120 - 130 mm they return back to the sea.

Adults

Sexually mature adults occur only in the sea. They are found in shallow coastal region with muddy sea bottom which are subject to changes due to the physical conditions of the coast line and the nutrients obtained from the land and rivers. In these areas upto about 80m they contributes to the fishery.

Bionomics and life history

Reproduction

Sexuality

The species is heterosexual. The sexes can be distinguished by morphologically differentiated external characters such as petasma on the first pleopod and appendix masculina on the second pleopod in male and thelycum on the thoracic sternite in female. Females attain relatively larger sizes than males.

Maturity

By studying the process of maturation of the species by ova diameter measurements Rao(1968) estimated the size of the females at first maturity as 130.2 mm. He also estimated the size of males at first maturity as 102 mm. Fertilization is external.

Fecundity

Ranges from 68,000 mature ova in female of 140 mm size to 7,31,000 in that measuring 200 mm. The estimated relationship of body length to number of eggs produced is Log F=-8.1277 + 6.0808 Log L. When F is the fecundity and L total length of the prawn in mm with a regression correlation coefficient of 0.9716.

Spawning

Spawning season extends from October-December to May-June in Cochin waters, with peak spawning in November - December and February - April. In Madras peak spawning activity was observed from May to September. Rao (1968) concluded that individuals spawn 5 times during their life time with an interval of 2 months between two successive spawnings. Breeding of the species takes places in the sea in relatively deeper waters.

Eggs

The largest ovarian eggs measure 0.304 to 0.384 mm in diameter. Recently Muthu, Pillai and George (1976) succeeded in getting the species spawned in the laboratory. The eggs measure 0.27 mm in diameter, with narrow perivitelline space.

Larval history

Muthu, Pillai and George (1976 and 1978) described the complete larval history consisting of 6 naupliar, 3 photozoeal and 3 mysis stages by spawning and rearing in the laboratory. The earliest post larval stage was observed 12 days after spawning. The diagnostic features of each stage are given by them.

Adult history

Greatest size

The maximum size attained by the species is 230 mm. The greatest size recorded in the backwater catches is 167 mm.

Food

Feeds on both vegetable and animal matters; vegetable matter includes diatoms, planktonic algae and seaweeds, and animal matter consists of small crustaceans, molluscs, polychaets echinoderm larvae, hydroids, trematodes and foraminifera.

Growth

Growth rate of the species varies from place to place. In the estuarine environment, juveniles grow at an average monthly rate of 10 mm in Cochin backwaters and chilka lake, 14.4 to 16.0 mm in Ennur and Adyar estuaries, 24.2 mm in Covelong backwaters (Madras) and 17.1 mm for males and 19.5 mm for females in Manakudy lake (Kanyakumari District). In the marine regions, the males and females of the species grow at an average monthly rate of 9.8 mm/7.2 mm respectively at Ambalapuzha (Kerala), 5.2/5.7 mm at Colachel and 5.6/7.0 mm at Madras. Recent studies on the age and growth of the species have indicated that males and females attain a length of 156/138 mm respectively at the end of first year and 189/181 mm at the end of second year of life.

Migration and movements

Apart from the imigration and emigration in and out of backwaters of larvae and sub adults respectively recent mark recovery experiments conducted at CMFRI (CMFRI 1982) has shown that this species migrates from the backwaters of Cochin to the south east coast of India upto Tirunnevelli coast, moving around Cap e Comerin.

Population

Sex ratio

Sexes are more or less equally distributed both in the estuarine and marine regions, although during certain months preponderance of females has been observed in many places.

Age and size composition

The fishery is supported by 0-year old prawns in the estuaries and backwaters and by 0-year as well as 1-year old prawns in the marine region. The principal size group supporting the fishery in the backwaters is 81-120 mm.. In the marine region, 96-175 mm prawns predominate the catches. Within this size range, the model size groups contributing to the fishery vary from place to place and from season to season.

Mortality

The estimated annual total mortality rate (Kurup and Rao 1974) in the fishery of Ambalapuzha is found to be 3.1 for males and 2.1 for females. Lalitha Devi (1986) estimated much higher rates of 12-73 and 9.42 for males and females respectively from Kakinada region.

Exploitation

Fishing gear

The species as well as the following species of penaeid prawns, are generally caught by stake nets, cast nets, drag nets, dip nets and scoop nets in the estuaries and backwaters, and by boat-seines, shore-seines and shrimp trawls in the marine region.

Fishing craft

In the fishery of this species along with other species small dug out canoes (4 to 6 m long) are in use in the backwaters. Larger dug out and plank built canoes (6 to 10 m long) and catamarans are used in the indigenous inshore fishery. The shrimp trawls are operated from 7 to 11 m pablo type wooden hull boats powered by 10 to 30 hp diesel engines. Some larger steel built boats are also operating shrimp trawls.

Fishing areas

P.indicus is fished commercially from almost all the estuarine and backwater areas and from areas upto about 80 m depth zone in the sea.

Fishing seasons

In the backwaters of Kerala the species is fished almost through out the year and in the marine fishery there is maximum abundance during January to April.

Fishing operations and results

In the backwater fishery this species forms approximately 12% of the catches. In the marine fishery it contributes to approximately 10% of the prawn catches. On the basis of this the total catch of the species per year is estimated as nearly 8,000 tonnes.

Fish farming

In recent developments in the culture of prawns in the country P.indicus is the most important species. Intensive prawn culture methods, involving the species are being developed and tried in different places.

2. Penaeus monodon Fabriculus

Distribution

This is widely distributed through the greater part of the Indo-West Pacific region ranging from South Africa to southern Japan. Along the Indian coast it is more common on the east coast especially in the northern section, although found in all areas.

Distribution at different stages of life history

No information is available on the distribution of eggs and larvae of the species. Post larvae have been reported in large numbers in the estuaries of West Bengal, Orissa and Andhra Pradesh. Increasing efforts are being made to find out new resources of post larvae to be used as seed for intensive culture of the species in almost all the estuarine areas of India.

The juveniles are found in the estuaries and backwaters and support commercial fishery in some areas.

Mature adults occur only in the sea and are obtained from comparatively deeper waters.

Bionomics and life history

Reproduction

Sexuality

P.monodon is heterosexual. The sex can be distinguished by the characteristic petasma in male and thelycum in female. Appendix masculine on the second pleopod of male has specific character. Females attain larger sizes than males.

Maturity

Attempts have been made to induce maturation and subsequent spawning in the species by the method of eyestalk ablation. Recently only successful maturation and spawning were achieved in Philippines and other places by this technique.

Fecundity

The number of eggs produced varies from 3 to 7 lakhs.

Spawning

Spawning takes place in the sea. Recent experiments have established the possibility of inducing spawning in the species by eyestalk ablation method. The possibility of the species breeding on the same grounds as P.indicus has been expressed by some authors.

Larval history

Along with the other species of commercial importance of Kerala this species has also been successfully spawned in the laboratory at Narakkal and reared from eggs through the entire larval stages (Silas et al 1978). Like in other

species there are 6 naupliar 3 protozoeal and 3 mysis stages in the life history. The occurrence of post larvae has been reported from Cochin, Adyar and Ennur backwaters.

Chilka lake and Gangetic delta

The post larvae about 10 mm long are transparent with a characteristic crimson streak running along the entire ventral surface, involving the whole of the antennules and the telson.

Adult history

Greatest size

In the trawl fishery of different centres along the coast of India specimens measuring over 300 mm in total length are common. Largest recorded size of the species is 337 mm.

Food

Food of the species consists of large crustaceans, vegetable matter, polychaetes, molluscs and fish. Small crustaceans and insects are taken occasionally.

Growth

In the Chilka lake the juveniles grow at a rapid rate of 25 mm per month. In the stake net fishery here the size of the species ranges from 76 to 190 mm, while at Bombay the sizes ranges from 100 to 150 mm. At Madras the growth of the species has been worked out as 160-170 mm in about 6 months in natural brackish.

Population

Age and size composition

On the basis of the growth rate recorded it is inferred that the commercial catches from the coasts of India is formed of 0-year class or early 1-year class prawns. In the stakenet

fishery of Bombay the size of the species ranges from 100 to 150 mm while in the Chilka lake fishery the sizes vary from 76 to 190 mm. In the trawl fishery of different centres along the coast prawns measuring over 300 mm are common. The species may attain a size of about 250 mm in one year.

Exploitation

Fishing gear

All the gears in use in the general prawn fishery are used for this species.

Fishing craft

Same craft as in other species.

Fishing areas

Although occurring in the marine and estuarine regions on both the coasts, commercial fishery for the species is found in Gulf of Kutch, Bombay, Kerala, Kanyakumari district, Cuddalore-Portonovo, Madras, Kakinada and Puri. The adults are caught in depths upto 110 m.

Fishing seasons

The species is caught throughout the year, peak season being from November to January in Gautami estuary, August to October in Bombay and December-January in the Chilka lake.

Fishing operation and results

10% of the Gulf of Kutch prawn fishery is constituted by P.monodon. The estimated catches of the species from the Gautami estuary in 1960-61 was 500 tonnes and the average rate of catch was 2.1 kg/day/net. In the annual average landings the species forms about 3%.

Fish farming

The species is cultured in the Philippines, Taiwan and other far east countries. P.monodon is selectively stocked and cultured in Kakinada and some other estuarine areas in India. Intensive culture methods involving this species along with P.indicus are being developed in different areas along the coast of India.

3. Penaeus semisulcatus de Haan

Distribution

Distributed in the tropical Indo-West Pacific ranging from Durban Bay through Red Sea, Indian waters, Malaysia, Indonesia to northern and north eastern Australia through New Guinea, Philippine Islands to South Japan. On the Indian coast this is more common on the east coast, although distributed on both the coasts.

Distribution at different stages of life history

Juveniles

Juveniles of the species are caught in appreciable numbers in the estuarine fishery of the west coast. In the Cochin backwaters the distribution and abundance of these juveniles is purely seasonal extending from December to June, disappearing from the environment in July when the salinity and temperature decrease due to monsoon rains and appearing again in December when these increase.

Adults

Adult specimens of the species form a predominent component of the prawn fishery in the Gulf of Mannar and Palk Bay. It also supports a minor fishery in the Tuticorin, Cuddalore - Portonovo regions, Madras and in the Sunderbans.

Bionomics and life history

Reproduction

Sexuality

Heterosexual, characteristic thelycum and petasma in females and males respectively. Females grow to larger sizes than males.

Maturity

In Tuticorin and Mandapam areas upto 35% mature females were obtained in the fishery during certain months. The size of the females at first maturity is 23 mm carapace length.

Fecundity

Ranges from 67,900 eggs to 660,900 eggs in prawn measuring 29 mm and 45 mm carapace length.

Spawning

June to September and January-February are the seasons of peak spawning in the Gulf of Mannar and Palk Bay, breeding taking place in the sea.

Larval history

Recently the larval history of the species has been traced by laboratory spawning and rearing of the larval stages at Madras (Devarajan et al, 1978). There are 6 naupliar, 3 protozoeal, 3 mysis and one intermediate stage. The post larvae resemble those of P.monodon.

Adult history

Greatest size

In the fishery of the east coast specimens measuring 200 to 230 mm length are common. Maximum size attained is about 250 mm.

Food

P.semisulcatus consume large quantities of animal matter viz., polychaetes, crustaceans, molluscs, radiolarians, foraminiferans and fishes as well as diatoms and algal filaments.

Growth

In the estuary the species grow upto a size of about 150 mm. The marine fishery is mostly composed of sizes of 120 to 220 mm, growth to the older sizes taking place in the sea.

Population

Sex ratio

The males and females are more or less equally distributed in the fishing grounds.

Age and size composition

The estuarine fishery of the species consisting of sizes upto 150 mm is composed of 0-year class prawns and the marine fishery of sizes upto about 230 mm by 0-year and 1-year classes.

Exploitation

Fishing areas

Commercial fishery for the species exist along the east coast in Tuticorin, Gulf of Mannar, Palk Bay, Cuddalore, Porto Novo, Madras and Sunderbans. Juveniles are found in the fishery of Cochin backwaters also at certain times.

Fishing seasons

Although present in the fishery in small numbers all through the year, the peak season in Cochin backwaters is January to May. In the Palk Bay and Gulf of Mannar the peak

fishery is in the months October to January. At Tuticorin the peak season is January to June.

Fishing operation and results

The estimated catch of the species in Mandapam region during the year 1977 was about 194 tonnes. Backwater catches at Cochin in 1972 amounted to 4.1 tonnes.

Fish farming

At present the species is not cultured in India. In view of the present success in spawning it in the laboratory, the possibility of the species getting a place in the intensive culture practices being developed in the country is bright.

4. Penaeus merguiensis de Man

Distribution

Widely distributed in tropical waters from West Pakistan eastward to New Caledonia, penetrating the Australian region southward. On the Indian coast the species is found in the fishery in the middle regions of both east and west coasts. In other areas it is found in small numbers along with P.indicus.

Distribution at different stages of life history

Larvae

Large numbers of larvae in advanced stages of development occur in the inshore waters as well as the estuarine system of Goa, as studied by George and Goswami (1977). Maximum occurrence of these larvae was noticed in the pre-monsoon months.

Post larvae

The distribution was studied by the same authors at Goa. The maximum ingression of these post larvae into the estuary was at hightide during monsoon months. Night collections contained more of these larvae and postlarvae than day collections.

Juveniles

Juveniles are caught in the fishery of estuarine areas wherever the species forms a fishery in the inshore waters. They are distributed in the estuarine systems of Goa, Karwar, Ratnagiri, Kakinada and Chilka lake.

Adults

The adults of the species contribute to fairly good fishery in the inshore waters of Ratnagiri, Goa and Karwar on the west coast and Kakinada and Puri on the east coast. It is also found, in very small numbers in other areas like south east and south west coasts.

Bionomics and life history

Reproduction

Sexuality

Heterosexual thelycum in female and petasma in male show diagnostic features. Females grow to larger sizes than males.

Maturity

At Goa during October to January larger females above 150 mm were dominant and most of them were mature. At Puri during the peak season of the fishery in October to December maturing and mature specimens dominated in the catches.

Fecundity

Although eggs have been reared through larval stages, no information is available on the number of eggs which have a diameter of 0.23 mm.

Spawning

The peak spawning season of the species in Goa waters, derived from the indirect evidence of occurrence of larvae and post larvae, seems to be from November to February with a secondary peak in April-May. The spawning population consisted of females ranging from 141 to 185 mm. November-December peak spawning is noticed at Puri also when females of sizes above 175 mm were either mature or spent.

Larval history

The larval development has been studied by laboratory rearing by Raje and Ranade (1972). The eggs are spherical, white and demersal. The nauplii hatched out in 18 to 24 hours. There are 5 naupliar, 3 protozoeal and 3 mysis stages before becoming postlarvae in about 13 days time after hatching.

The diagnostic features of the protozoea larvae of this species for differentiating from those of P.indicus are the absence of bifurcate orbital spine in the second protozoea. The presence of postero lateral spine on the 4th abdominal segment is the important difference in the post larva.

Adult history

Greatest size

In the fishery specimens upto sizes of about 240 mm have been obtained.

Food

Growth

Length frequency distribution studies at Goa indicated the rate of growth in females to be 10 mm per month and that in males 5 mm per month. In Puri the growth rate was slightly lower than this. The tagging experiments conducted at Goa, however, indicated a growth rate of about 27 mm per month in the younger sizes.

Population

Sex ratio

In the population of the species at Goa dominance of females was noticed. In Puri region the catches of the species showed preponderance of females except in July. Sizewise analysis of sex ratio showed that there was little variation in the male to female ratio in sizes below 150 mm. But above this size females were by far in excess of males.

Age and size composition

At Karwar the model size of the species caught by trawl net is 141-150 mm* In Puri the dominant size groups in the fishery in October to December was 161-180 mm. Smaller sizes were seen to enter the fishery in January. In Goa in the trawl catches from October the sizes of females ranged from 96 to 190 mm and in males from 101 to 160 mm. By July the larger specimens disappeared from the ground and during the rest of the season females of 135-146 mm and males of 130-140 mm size groups dominated in the fishery. In the gill net catches from the river mouths in the monsoon months males ranging from 95 to 165 mm and females ranging from 95 to 195 mm were caught with dominant sizes for males at 130-150 mm and females at 140-160 mm.

The juveniles population in the estuary belonged to the 0-year class while in the marine fishery 1st and 2nd year classes are included.

* and that by shore seine 111-115 mm.

Exploitation

Fishing gear

At Karwar the species is mainly caught by shore seines and trawl nets. In the inshore fishery trawl nets are operated for catching the species in other areas also.

Fishing areas

It contributes to commercial fishery only in certain areas such as Ratnagiri, Goa and Karwar on the west coast and Kakinada and Puri on the east coast. Small quantities are fished from the Gulf of Mannar and Palk Bay region. Juveniles are found in the estuarine areas of these respective areas.

Fishing season

In Goa region the peak season of fishery of the species is during the post and pre monsoon months. In Karwar the species is fished mainly during the monsoon months. At Kakinada maximum catches are obtained from January to June. At Puri the peak season is from October to December.

Fishing operation and results

The trawl catches of the species at Kakinada during 1972 and 1973 were 5.4 and 4.2 tonnes respectively. At Puri the catches during the same years were 359 and 110 tonnes respectively.

Fish farming

Efforts for mass culturing of the larvae of the species by laboratory spawning and subsequent rearing of larvae and rearing the juveniles thus obtained to adult sizes are being made at the Marine Biological Station at Ratnagiri.

5. Metapenaeus dobsoni (Miers)

Distribution

Distributed in Indian waters through Malaysia and Indonesia to Philippines Islands. Towards the west it is found in the Gulf of Aden through the coast of Pakistan. In Indian waters the species is present in inshore waters upto a depth of about 40 m and the juvenile stages in the estuaries of most of the coastline. More common along the west coast from Goa to Quilon, forming a major fishery.

Distribution in different stages of life history

Eggs and larvae

Eggs and larvae of M.dobsoni are common at the surface and near the bottom in depth ranging from 3 to 25 m near estuaries between Quilon and Goa. The distribution of larvae of the species in Cochin waters, and the waters of Goa have been particularly studied by several authors. They are most abundant from September to April.

Post larvae

The early post larval stages migrate into the various estuaries and backwaters along the Indian coast. In the Cochin backwaters quite a large proportion of the post larvae enter before they reach a length of about 7 mm. The post larvae are found to occur throughout the year with peak abundance in June through August and November-December. In the estuaries and inshore waters of Goa the post larvae are most abundant in January to May.

Juveniles

The juveniles are present in most of the estuaries throughout the year and contribute to major part of the fishery in most months.

Adults

Adults are most abundant in the indigenous fishery of Cochin area from May-June to September-October and in the mechanised fishery from October-November to June-July. In Goa region the adults are abundant from October to February-March. Concentration of adults of the species are found to occur in places of mud bank, "chaakara", formation along the south west coast of India.

Bionomics and life history

Reproduction

Sexuality

Heterosexual, Thelycum and petasma present in female and male respectively. Females attain larger sizes than males.

Maturity

The size of the female at first sexual maturity is 64 mm and that is estimated as belonging to late 0-year class. Fertilization is external as in other species of penaeids.

Fecundity

Fecundity ranges from 34,500 eggs in 70 mm size prawn to 160,000 eggs in 120 mm size. The estimated relationship of body length of the prawn to the number of eggs is log $F = -07175 + 2.8473 \log L$ where F is the fecundity and L total length in mm. Thomas et al (1974) got 50,000 eggs spawned in the laboratory.

Spawning

In Calicut the spawning season of the species, is reported from September to April with peak in September to January. In Cochin waters there is spawning throughout the year with peaks in April, June through August and in November-December. In Goa region the peak spawning is noticed from January to May.

It is estimated that individual specimens spawn 5 times during the life time with an interval of 2 months between successive spawnings.

The species breeds in the inshore waters inside the 25 mm depth region.

Eggs

The most highly developed ovarian eggs measure 0.32 mm in diameter. The newly spawned eggs measure 0.35 to 0.44 mm.

Larval history

Development of the species through 3 to 5 naupliar, 3 protozoeal, 3 mysis and 13 post larval stages was described by Menon (1952) and Rao (1973). Thomas et al (1974) describe 6 naupliar stages and Muthu et al (1978) 5 mysis and 2 intermediate stages as a result of spawning in the laboratory. The nauplius phase in the life history lasts from 24 to 43 hours. First post larva was observed 13 days and 8 hours after spawning.

Adult history

Greatest size

About 130 mm in total length is the maximum size attained by the females of the species.

Food

The food in general consists of varying amounts of organic matter mixed with sand mud, copepods, nematodes, amphipods, gastropods, lamellibranchs, algae like Cladophora and diatoms such as Fragilaria, Coscinodiscus, Pleurosigma, Cyclotella etc form the major components of food items. The species is generally considered as a detritus feedor.

Growth

The growth rates estimated by earlier workers by the length frequency method seem to be on the lower side when compared with the fast growth rates noticed in the intensive culture experiments. The juveniles grow in the estuarine environment at an average rate of growth of about 10 mm per month.

Migration and local movements

As in other penaeids, the life cycle is completed in two environments, namely the brackish waters and the sea. So regular movements of younger stages into the backwater and the older sizes back to the sea takes place. Apart from the larval migration to the backwaters, a size oriented, sex-wise movement has been observed in the inshore waters of Cochin. The movement of the adult population into mud bank areas has been recorded.

In the Godavari estuary emigration and immigration of the species has been found to be more intensive during the new moon days than during full moon days. Immigration of large numbers of juveniles into the estuary takes place during dawn.

Population

Sex ratio

A size oriented sex ratio difference was noticed in the fishing grounds of Cochin. The distribution of the sexes varies significantly from month to month. This differential sex ratios may be the result of breeding migrations of females.

Age and size composition

The life span of the species is estimated to be about 2 years, males and females attaining respectively lengths of 97/115 mm at the end of first year and 122/135 mm at the end of second year. Thus the bulk of the commercial fishery both in the back waters and in the sea is supported by 3-12 months old prawns.

Mortality

The total annual instantaneous mortality rate in the trawl fishery of the species at Cochin estimated by two different methods show an average of 3.21. The estimated annual total mortality rate for the males and females in the fishery at Ambalapuzha is 3.8 and 3.1 respectively. Alagaraja et al (1986) estimated instantaneous total mortality of the species in Cochin harbour fishery for 1980 and 1981 at 1.00 with standard error 0.23.

Exploitation

Fishing gear and fishing craft

These are the same as in other penaeid prawns. In addition in recent years the species has been obtained in large concentrated shoals in purse seine catches off Cochin and Mangalore in the month of September (Sukumaran, 1985)

Fishing areas

The main fishing areas are the inshore waters of the west coast from Goa to Quilon. In a depth region upto 40 m and inshore waters of Andhra Pradesh and Orissa. Juveniles are fished from the estuaries and backwaters.

Fishing seasons

In the backwaters the fishing is done throughout the year. In the paddy fields of Kerala the fishery is seasonal from middle of November to middle of April. In the indigenous fishery in the inshore waters of the southwest coast the specie is most common in May-June to September-October. In the trawl fishery the peak season of the fishery is from November-Decembe to March-April. In Goa region the species is most abundant in the fishery from October to February-March.

Fishing operation and results

The percentage composition of the species in the all India penaeid prawn landings is about 34%. Wide fluctuations in the catches are noticed in various centres from year to year. Thes are probably fluctuations due to natural causes.

Fish farming

M.dobsoni is the most important species in the paddy field prawn filtration practiced in Kerala backwaters in which very little culture of the species is involved, apart from the trapping of adoloscent stages. Large scale culture practices of the species are involved in the intensive prawn culture methods.

6. Metapenaeus affinis (H.Milne Edwards)

Distribution

General distribution of the species in Indian seas through Malaysia and part of Indonesia to Hongkong and Japan. In Indian waters juveniles are found in small numbers in the backwaters and estuaries and adults contribute to the fishery of the inshore waters upto a depth of about 45 m in most of the coastal areas.

Distribution in different stages of life history

Larvae

George & Goswami (1977) described the distribution of larvae of the species in Goa waters and central west coast and the occurrence in large numbers in January to March.

Post larvae

The occurrence of post larvae of the species is reported from the inshore waters of Goa. There does not seem to be much large scale migration of the post larval stages into the estuaries as in the case of M.dobsoni and other species.

Juveniles

Juveniles are found to a certain extent in the fishery of several of the estuaries. But the species never accounts for more than about 10% of the catch in the fishery for juvenile prawns in the backwaters of Cochin. It is more commonly found in the fishery from January to June.

Adults

In the fishing grounds of the west coast of India adults of the species are most common in November-December and January. Adults are found in the coastal fishery of most of the areas of the country.

Bionomics and life history

Reproduction

Sexuality

Heterosexual. Thelycum and petasma present in male and female respectively. Females attain larger sizes than males.

Maturity

The size of female at first maturity is 88 mm at the late 0-year class. As in other penaeids fertilization is external.

Fecundity

The number of eggs in the well developed ovary ranges from 88,000 to 363,000 in specimens measuring 95 mm and 160 mm respectively. The estimated relationship of body length to the number of eggs is log F=-0.4306 + 2.7179 log L where F is in the number of eggs and L is the total length in mm.

Spawning

In Cochin waters the breeding season is from October to March with peak in November, December, January to March is the spawning period in Calicut and Goa waters. In Bombay waters the peak spawning is in October and April to June.

It is estimated that the species spawns more than once during its growth from 90 mm to 160 mm.

There are indications that the species moves to slightly offshore areas for spawning. In Cochin it is found to breed in waters of depth 25-45 m.

Eggs

The ovarian egg at maximum development measures 0.352 mm in diameter. The eggs spawned measure 0.23 - 0.25 mm. The embryonic mass measures 0.14 mm, the rest of it being perivetelline space.

Larval history

The larval development of the species has been described by Thomas et al (1974) as a result of laboratory spawning and rearing. There are 6 nauplius, 3 protozoea and 3 mysis stages. Muthu et al (1978) described 5 mysis and 2 intermediate stages. First post larvae is reached in about 12½ days after spawning.

Adult history

Greatest size

170 mm is recorded as the maximum size to which the species grows.

Food

The species is reported to feed mainly in vegetable matter. The items of food in their order of abundance in stomachs are vegetable matter, small crustaceans (copepods and ostracods) polychaets, echiurid setae, molluscan shell pieces and fish remains. The species is an omnivorous feeder and larger prawns show a preference to a molluscan diet.

Growth

In the trawl catches of Cochin a growth of 20 mm in males and 25 mm in females in about 6 months was recorded in the larger sizes of 1-year class. In the Goa coast the species grows at an average monthly rate of 6.6 mm in females and 4.0 mm in males. Still lesser growth rates have been recorded at other areas by studying the length frequency. In culture

experiments it may show higher growth rates as in other species.

Migration and local movements

The migration of this species to estuaries is very much restricted when compared to the other species of the genus. In the Godavari estuary the immigration of juveniles was noticed to be most marked at dawn and emigration during night.

In the offshore shrimping grounds off Cochin the species moves to deeper waters during the monsoon period and return after the monsoon.

Population

Sex ratio

Sexes are found to be equally distributed upto a size of about 120 mm. Among older prawns above this size females dominate in the catches of the south west coast. Domination of females was reported in the catches of other areas also.

Age and size composition

In the trawl fishery of Cochin the 1st and 2nd year classes are represented. The 2nd year classes generally enter the fishery in the earlier half of the season and the 1st year classes appear in the later half. The late 0-year class is also represented in some months. In the backwater fishery the 0-year class is represented to a limited extent.

From October to January larger sizes with length between 121 and 140 mm are represented in large numbers. After February smaller sizes are represented in the fishery in most of the areas of the fishery. In Goa and Bombay waters the sizes of the prawns in the fishery ranged from 45 and 170 mm.

Exploitation

Fishing areas

The main fishing areas are the inshore waters upto about 50 m. In the fishery of Cochin a concentration of the species is noticed at 18-20 m depth region. In Bombay waters the main fishing areas are in depth regions inside 15 m. Juveniles are fished to a limited extent from the estuaries.

Fishing seasons

In the backwater fishery of Cochin the species is most abundant from January to June. In the inshore and trawl fishery the main season is from October to May with peak in November-December to February.

Fishing operation and results

The percentage composition of the species in the prawn fishery of the country is about 9.6%. The total catch of the species in the trawl fishery of Cochin for the season 1959-60 ranged from 479 kg to 14182 kg. The catch per hour ranged from 1.6 kg to 22.9 kg in the case of this species.

Fish farming

In the paddy field prawn filtration fishery practised in Kerala backwaters, the percentage contribution of this species is very little. The recent success in the spawning of the species, in the laboratory may prove useful in its culture.

7. Metapenaeus monoceros (Fabricius)

Distribution

Widely distributed from South Africa through Mediterranean and Indian seas to Malaysia. In India it occurs along the entire coastline, found in juvenile stages in estuaries and adults in the sea upto 60m depth areas.

Distribution in different stages of life history

Larvae

Distribution of the larvae of the species was studied by Rao (1973) in Cochin waters. George & Goswami (1977) described the distribution of the larvae in the estuaries and inshore water of Goa and reported their peak occurrence from November to February.

Post larvae

The occurrence of post larvae of the species has been reported from several estuarine areas and their distribution has been used as an indirect evidence to find out the spawning season of the species. The post larval recruitment into the backwaters of Cochin was studied showing their peak occurrence in November-December and July-August.

Juveniles

The juveniles are present in the estuaries and backwaters and contribute to a fishery in most of these inside waters like Cochin backwaters, Gangetic delta area and others.

Adults

The adults are found in the sea slightly deeper waters than the other species of Metapenaeus, upto about 60 m depth region, contributing to a fishery in most of the coastal areas.

Bionomics and life history

Reproduction

Sexuality

Heterosexual Thelycum in female and petasma in males diagnostic of the species. Females attain larger sizes than males.

Maturity

By indirect evidences it is concluded that the species do not attain maturity before reaching a length of about 120 mm. Fertilization is external.

Fecundity

Number of eggs produced by females of the species varied from 155,000 to 338,000 (Nalini 1976).

Spawning

A spawning ground of the species was located in the 50-60m depth area off Cochin.

Peak spawning period is recorded as July-August and November-December. In the Gulf of Kutch area the spawning season is from February to April.

Eggs

The eggs spawned in the laboratory measure 0.35 mm in diameter and are spherical and brownish in appearance. They hatch out in 18 to 24 hours.

Larval history

According to Raje and Ranade (1972) the results of laboratory rearing showed 5 naupliar, 3 protozoeal and 5 mysis stages. The recent experiments by Mohammed et al (1978) gave 6 naupliar, 3 protozoeal and 6 mysis stages by laboratory culture.

Adult history

Greatest size

The species grows to a maximum size of 190 mm.

Food

Feeds mostly on small crustaceans like amphipods, isopods copepods and Tanaidacea. Polychaet remains vegetable matter and molluscan shell remains are other food items. A size wise difference is noticed in the feeding of the species. Selective feeding of different size groups are recorded by George (1974).

Growth

By laboratory rearing an average growth rate of 7.98 mm per month was recorded in the species. In the paddy field fishery George (1975) has recorded a growth rate of 0.47 mm/day for juveniles, amounting to 14 mm per month. In the Gulf of Kutch area these prawns are reported to attain 102 mm in 5 months period.

George (1959) recorded 32 moults during a period of growth of the species from 3 mm to about 100 mm.

Migration and movements

In the offshore trawling grounds off Cochin movements of the bigger sizes into the ground from deeper waters was observed in the early half of the season in November. In the Gulf of Kutch area these prawns are noticed to move to deeper waters and open areas from August to November.

In the Godavari estuary migration out of the estuary was mostly nocturnal and immigration was greatest at dawn. The outward migration was most intense in December, May and June.

Population

Sex ratio

A slight dominance of females has been noticed in the juveniles in the backwater catches.

Age and size composition

The estuarine fishery is generally supported by prawns measuring less than 100 mm with dominant sizes ranging from 55-90 mm. These prawns belong to the 0-year class. In the marine fishery the size of the species range from 90 mm to 175 mm, bulk of the catch being composed of by prawns measuring between 125 mm and 150 mm. 2 or 3 year classes are probably represented in these catches.

Exploitation

Fishing areas

The fishery for juveniles is largely in enclosed or partly enclosed waters such as paddy fields, estuaries and lagoons in waters of less than 5m depth. Adults are fished in depths upto 60 m off Cochin.

Fishing season

The species is fished through out the year in the backwaters with the peak season in March to June and November. In the marine fishery of Cochin the peak season is November-December. In Bombay waters the peak fishery is during the rainy season July and August. In the Godavari estuary the species is most abundant in May to June and November-December.

Fishing operation and results

In the trawl fishery for prawns off Cochin in the years 1958-63 the total catches of M.monoceros in the months in which it was fished significantly, mainly November,December, varied from 0.65 tonnes to 3.9 tonnes. The catch per hour for the species varied from 2.3 to 21.3 kg. The percentage composition of the species in the prawn fishery of the country is about 4.5%.

Fish farming

The juveniles of this species are fished in the paddy field prawn filtration fishery of Kerala backwaters along with other species. Apart from this culture of the species is not* laboratory in Cochin and Ratnagiri may prove useful in its culture.

8. Metapenaeus brevicornis
(H.Milne Edwards)

Distribution

The species is distributed from West Pakistan through Indian, Malaysian, Thai and Indonesian waters to about East Borneo. In Indian waters M.brevicornis has a more northerly distribution when compared to the other species of Metapenaeus contributing to the fishery in the northern region both on the west and east coasts.

* carried out. The recent successes in the spawning of the species in the

Distribution in different stages of life history

Juveniles

Juveniles occur throughout the year in the upper and middle reaches of the Hooghly estuarine system, most common from July to November. Juveniles and young adults also occur throughout the year in inshore waters near Bombay. The species is found in Godavari estuary also.

Adults

Mature adults are found in the lower reaches of the Hooghly estuary as well as off shore waters of Bombay.

Bionomics and life history

Reproduction

Sexuality

Heterosexual. Female has thelycum and male possess petasma with specific characters.

Maturity

According to Rajyalakshmi (1961) the species attains maturity at a length of about 100 mm. But Bhimachar (1965) gave the size at maturity as 75 mm length. Fertilisation is external.

Spawning

In the Hooghly estuarine system the species is reported to have 2 spawning seasons, one in the early summer, March and April and the other in the monsoon months July and August and the spawning takes place in the marine zone of the estuary and the inshore areas. In Bombay waters mating

is reported to take place in shallow water and the females migrate to deeper waters for spawning. At Kandla the species breeds during March, April.

Larval history

Rao (1978) worked out partly the larval development of the species. 6 naupliar, 3 protozoea and 1 mysis stages have been described by him.

Adult history

Greatest size

The maximum size attained by the species is reported to be about 135 mm.

Food

The items of food in their order of abundance are vegetable matter mainly consisting of angiosperm tissue and filamentous algae, small crustacean remains, appendages and other remains of large crustacea, remains of fishes, molluscan shell remains and polychaeta. Sand grains are also present.

Growth

In the Hooghly region the males and females of the species attain lengths of 45.8/47.4 mm respectively at the end of first year of life and 85.0/89.0 mm at the end of second year of life. Juveniles grow approximately at a rate of 3 mm per month. More or less similar growth rate is recorded in the fishery at Kandla. This growth rate appears to be very slow when compared to the results obtained in culture experiments in other allied species.

Faster growth rate in females is recorded in Hooghly in summer when the temperature and salinity of the estuarine waters are high, medium during rainy season when the salinity is low and temperature fairly high and low during winter season when high salinity and low temperature prevail.

Migration and local movements

In Hooghly estuary the adults migrate to the lower reaches and inshore areas for breeding and the young migrate up the estuary. In Bombay waters adult females migrate away from the inshore areas for spawning. In Godavari estuary emigration reached the peak in May commencing from January, mostly during day time. Immigration was at the maximum at dawn.

Population

Sex ratio

In most of the month female are found to dominate in the catch both in Bombay and Hooghly.

Age and size composition

The size of the species ranges between 15 and 115 mm in the estuarine fishery of Hooghly. In Bombay waters the sizes ranges between 40 mm and 110 mm. In the Kutch region the creek fishery is composed of sizes between 26-55 mm and the inshore fishery by sizes of 66-135 mm.

In the lower reaches of the upper zone and the upper reaches of the middle zone of the Hooghly estuary 1 and 2 year groups form the fishery, the former dominating in most of the months. In the lower middle and the lower zones 0 and 3 year groups also contribute to the fishery, the 0-year group appearing between July and December.

Exploitation

Fishing gear

In the Hooghly estuarine system bag nets (bhinjal and thorjal) form the main type of gear and account for nearly 90% of the total catch. Small drag nets and dip nets account for the rest of the landings of the species.

It is also caught in barrier nets (Kalpata Jal). In Bombay coast the dol net or bag net and its variant bokshi are the main gear for catching this species along with other prawns.

Fishing crafts

The species is generally fished without the help of boats in the Hooghly estuary.

Fishing areas

The species has a fishery in the northern parts of both west and east coast, fished in the estuaries and inshore waters of these areas. In Bombay the species is caught in shallow waters varying in depth from 7 to 13 m. In Hooghly also it is fished in shallow waters.

Fishing season

July to February is the main season for the species in the Gulf of Kutch area. Along the Bombay coast the peak season is from January to March. In the Hooghly estuarine system, although it is fished through out the year, the bulk of the landings is in the winter months November to February. The main fishing season commences in August and continues to March. In the Godavari estuary the season is from March to June.

Fishing operation and results

About 30% of the total prawn catch of Hooghly estuary is contributed by this species. In Bombay waters in 1952 to 1954 the species averaged 12.8% of the total prawn catch. In Gulf of Kutch region the contribution of the species to the fishery varies from 13.7 to 27.4%.

Fish farming

The species is not cultured in any part of the country.

9. Parapenaeopsis stylifera (H.Milne Edwards)

Distribution

General distribution of the species is from west Pakistan and India and Ceylon waters through Malaysia to Indonesia and Borneo. In Indian waters it is distributed all along the coastline, more especially on the west coast and south east coast and is one of the most important commercially exploited species.

Distribution in different stage of life history

Eggs

Very little information is available on the distribution of eggs of the species. Eggs are liberated in shallow waters at a depth of 18-22 m. Eggs which seem to belong to this species have been collected from the inshore waters of Cochin in October.

Larvae

Early larval stages including protozoea and mysis stages occur in the inshore waters of Cochin from October to May. The distribution of the larvae of the species in Central West coast has been studied by Goswami et al (1977). Large numbers

of these larvae are distributed in the inshore waters of Goa and this has been studied by George and Goswami (1977). Contrary to the earlier understanding that the species is strictly marine without an estuarine phase in the life history, larvae of the species have been found to be distributed in the estuaries of Goa, especially nearer the mouth.

Post larvae

Post larvae are distributed in the inshore waters of Cochin, central west coast and Goa.

Juveniles

Juveniles ranging in size from 10 to 20 mm have been found in the months December to June in Calicut waters. Juveniles are distributed in the inshore waters of the areas where the speciesoccur in the fishery.

Adults

On the west coast of India the adults of the species is most abundant from Veraval to the Trivandrum coast, but moderately available in the Sind, Makran and Kutch areas. It is found in smaller numbers in the east coast.

Bionomics and life history

Reproduction

Sexuality

Heterosexual. Petasma and thelycum in males and females respectively have diagnostic features. Females grow to larger sizes.

Maturity

The size of females at first maturity is 63.2 mm in the 1st year of its life. As in other penaeids fertilisation is external.

Fecundity

The number of eggs in mature specimens ranges from 39,500 to 236,000 in size of 70 mm and 120 mm respectively. The formula for the relationship between the fecundity and total length is given as Log F= -1.5746+3.3437 Log L where F is fecundity and L total length. The coefficient of correlation (r) is 0.8079.

Spawning

Individual prawn spawns 5 times during life time with a gap of two months between successive spawnings.

The species breeds throughout the year, but peak spawning season varies from place to place. At Bombay the peak spawning is from December to May. In Goa waters the peak of spawning seems to be from December to February. Along the Malabar coast the peak occurs during October-December. At Cochin November-January and April are the peak spawning season and October to December at Ambalapuzha.

Larval history

The larval development of the species has been described by Rao (1973) and Muthu et al (1978) by laboratory spawning and rearing. While 6 naupliar, 3 protozoea and 3 mysis stages in the development of the larvae have been described by Rao (1973), 7 mysis stages have been described by Muthu et al (1978).

Adult history

Greatest size

Maximum size reached is about 145 mm.

Food

The species feeds mainly on small crustaceans like Copepods, Cirripeds (cypris larvae), mysids, amphipods, larval decapods, minute gastropods, bivalves and foraminiferans. Vegetable matter other than diatoms is rarely found in the stomach contents. As in other penaeids the stomachs also contain a considerable amount of sand and mud.

Growth

In Cochin waters the growth rate recorded is 15 mm for males and 20 mm females in the size range of 81-110 mm during a period of 4 months. At Bombay a monthly growth rate of 10 mm is observed in the population ranging in size from 51-55 mm to 81-85 mm for males and 61-65 mm to 91-95 mm for females. At Ambalapuzha the average growth rate is found to be 5 mm per month.

Migration and local movements

In the inshore waters annual migratory movements are noticed. The shoreward movement commences in October. Towards the end of May after the commencement of the south west monsoon these prawns move into slightly deeper waters. The larger prawns are the first to leave the inshore waters and these are followed by younger ones.

Population

Sex ratio

In the population, males predominate in the smaller size groups and females in the larger size groups and females are predominant for 6 months from January to June coinciding with

the peak breeding season. Segregation of females during the breeding period is noticed at Cochin also.

Age and size composition

It is estimated that the species attains a size of 63.3 mm, 91.4 mm, 108.7 mm and 117.2 mm respectively when they are 6, 12, 18 and 24 months old. Thus bulk of the fishery is supported by 7-12 months old prawns.

Although the size range of species encountered is 10 mm-145 mm the fishery is supported by 51-120 mm size groups.

Mortality

In the prawn fishery at Ambalapuzha the total mortality has been estimated by Kurup & Rao (1974). The annual total mortality of the species is estimated to be 3.9 and 2.9 in males and females respectively. Alagaraja et al (1986) estimated the total instantaneous mortality of the species at Cochin Harbour and Sakthikulangara (Neendakara) in Kerala for 1981 and 1982 fishery for males and females separately. The mortality figures are 1.19 and 1.33 for males and 0.70 and 0.58 for females at Cochin fisheries harbour and Sakthikulangara respectively.

Exploitation

Fishing gear and fishing craft

The species contributes to good fishery in the entire areas of the west coast in the inshore waters upto about 40m depth. In the southernmost region of the west coast, south of Trivandrum and along the east coast the species is found in lesser numbers.

The peak fishing season is from October to December at Veravel, September-October and January to May in Bombay, April, July-August at Karwar, January to April at Cannanore, February to May in the Malabar coast and September-October, January-February and April-May along the south west coast.

Fishing operation and result

The contribution of this species to the annual shrimp landings of the country is about 30%. In recent years there has been an increase in the contribution of this species in the fishery, thus becoming the most abundant species.

At Karwar in 1965-66 the landings of the species was 0.8 tonnes. At Mangalore the species form s 31.5% of the total estimated landings of 1030.4 tonnes. At Cochin the average monthly catch of shrimps landed by mechanised vessels has been estimated as 311 tonnes and the percentage of P.stylifera varies in different months from 2.8 to 40.2. The fishing of this species has become more prominent with the commencement of the monsoon season shrimp trawl fishery at Sakthikulangara near Quilon in Kerala, where nearly 80% of the catches are being contributed by this species.

10. Parapenaeopsis hardwickii (Miers)

Distribution

Distributed in the northern part of the west coast and east coast of India through Malayasia to Southern China. In Indian waters it is found in the coastal waters from Goa upwards on the west coast and mostly along the Andhra area in the ~~west~~ east coast.

Bionomics and life history

In Bombay waters the species spawns from October to February with maximum intensity in December,January. Maximum size reached is bout 140mm.

Population

The population of the species found in Bombay showed wide disparity of the sizes of males and females. The females were recorded upto a size of 125 mm while the largest male was only 85 mm. The percentage of males in the catches are also poor. In the distribution of the sizes it is noticed that the size range of females begin from the point where the size range of females end. Mohammed (1967) was of opinion that this may be due to the phenomenon of sex reversal (protandrous hermaphroditism), although he has not attempted to establish the fact. In Kakinada the sizes ranged from 50 mm with modal sizes 105-119 mm.

Exploitation

The species contributed to a fishery in Goa coast, Maharashtra coast and Kakinada coast, although the fishing season is limited to a few months. Along Maharashtra coast when it contributes to the maximum fishery it appears in the catches from November onwards, with peak occurrence in December and January. In Kakinada coast the species has the peak fishery in August - September and forms 3.4% of the total prawn fishery of the area.

11. Parapenaeopsis sculptilis (Heller)

Distribution

The species has a general distribution from west coast of India to Hong Kong, through Malaysian waters and Indonesia and also tropical Australia and New Quines. In India it is found in Goa and Maharashtra waters on the west coast and Andhra coast upwards in the east coast.

Bionomics and life history

It grows to a maximum size of about 175 mm. As in the case of P.hardwickii the cultrate rostrum in adult males is a characteristic feature of the species.

Population

In Karnataka area the trawl fishery contained specimens ranging in size from 65 to 175 mm with major size groups varying from 115-140 mm. At Bombay the species appears in larger quantities from November to January.

Exploitation

P.sculptilis contributes to a fishery in Maharashtra and Andhra coasts. Along Maharashtra the fishing season commences from November, reaching the peak in December and January. In Kakinada coast the maximum fishery is noticed in September, although found in small quantities throughout the year.

12. Solenocera crassicornis (Milne Edwards)

Distribution

The species is distributed from the Indian coasts to Malaysia. In India it is found all along the west and east coasts, but in larger numbers in the Maharashtra and Andhra coasts.

Bionomics and life history

In Bombay waters the ovary in females begins to mature at 51 mm length and of age 5 to 6 months. Since the immature ovary takes about 3 months to attain the mature stage, the prawn may spawn for the first time when it is 8 or 9 months old. The male attains sexual maturity at a length of about 50 mm.

In Maharashtra coast the species spawns from October to May with two spawning peaks in December and April. The main spawnings ground is just outside the fishing grounds inside the 40 mm depth region. The diameter of ovarian egg was found to be 0.17 to 0.25 mm.

The estimated growth per month in prawns over 33 mm length at Bombay was 6.96 mm for females and 6.49 for males. Recruitment of juveniles of both the sexes was evident in January to March, probably the progeny of the peak spawning in November, December. So the younger prawns appear to grow at a faster rate.

The estimated life span of the female is 14 to 15 months and that of male 9 to 10 months. The stomach contents in their order of abundance were crustaceans (44.7%), debris (25.8%)., fish (22.1%), polychaetes (2.9%), molluscas (1.9%), and grains (1.9%) and miscellaneous items (0.5%).

Kunju (1968) found two types of migratory movement, one in connection with spawning and the other in relation to salinity. For spawning the females move out of the fishing ground to slightly deeper region in peak periods of spawning in December and April. The population enmasse moves offshore when the salinity of the coastal waters decreases from June to early October.

Population

In Bombay waters the females are found to be twice as many as males. There is wide disparity in sizes of males and females with their modes widely separated. The possibility of protandrous hermaphroditism in the species is suspected by Mohamed (1967). At Kakinada the species in the fishery ranged in sizes of 40-116 mm, with sex ratio of males to females 1:4.

Exploitation

The species is commercially exploited from within 30 km from the coast near Bombay and to a lesser extent along the Andhra coast. The fishing grounds do not exceed 40 m in depth. In Bombay the fishery is operative throughout the year, excepting the period from June to September, with peak fishing in November and December. At Kakinada the maximum landings are in January to May and August, September. Factors like force and duration of tidal currents, rainfall, upwelling of coastal waters and depth influence the fishery in Bombay.

13. Nematopalaemon tenuipes (Henderson)

Distribution

The species belonging to the family Palaemonidae occurs in superficial coastal waters upto a depth of about 20m as well as in estuarine and brackish waters. It has a general distribution from Indian waters through Malaysia to New Zealand. In Indian region it occurs mostly in the northern areas of both the east and west coasts where it contributes to good fishery.

Bionomics and life history

The maximum size attained is about 72 mm. Females attain larger sizes than males and the largest male and female obtained at Bombay were of total length 61 mm and 72 mm respectively. The species, breeds almost throughout the year. However, the peak breeding is in the monsoon season from June to October.

The stomach contents of N.tenuipes were mostly debris and crustacean remains. Nearly 2.9% of the specimens in Bombay area were parasitised by bopyrids. The infected specimens failed to get mature and their growth in sizes also was affected.

Population

The population of this prawns in Bombay waters showed domination of females except during the June-September monsoon period when breeding is at the peak. The sizes of the prawns in the population ranged from 22 mm to 72 mm with average sizes of males between 35-50 mm and females 40-60 mm. At Kakinada the sizes ranged from 16 to 99 mm with modes at 32 and 42 mm. Females predominated in the catches here.

Exploitation

The species contributes to the fishery to a considerable extent along Maharashtra and Gujarat on the west coast and also northern part of east coast. In the waters of Bombay as well as in the Gangetic delta area the species is one of the most important commercial prawns. In Bombay the fishery extended from January to June with maximum landings in April and May. In July-September also there were good landings. At Kakinada maximum catches were found in May and August. Among the non penaeid prawns N.tenuipes contributed to 32% in Bombay, 60% at Veraval and 19% at Kakinada.

14. Acetes indicus H.Milne Edwards

Distribution

General distribution is from Indian seas through Mergui Archipelago and Gulf of Siam to Malaya and East Indies. In Indian seas it is most common in Bombay waters contributing to a substantive percentage of the fishery.

Bionomics and life history

This is the largest among the shrimps of the family Sergestidae, females reaching 40 mm in total length. The larval development of the species has been studied by Pillai (1973). The egg is 0.36-0.40 mm in diameter, occurring in the plankton of Bombay waters in plenty during October-November. 3 naupliar, 3 protozoeal, 1 mysis and 5 postlarval stages have been described. The relatively larger sizes of the larvae and presence of prominant rostrum are diagnostic features of these larvae. The seasonal distribution of the larvae shows that they occur abundantly during October-January, indicating this to be the breeding season of the species.

Population

The sizes in the fishery varied from 15 to 40 mm. In the northern region of the west coast of India it appears in vast shoals in the inshore waters and estuaries almost throughout the year.

Exploitation

The species is exploited to the maximum extent along Maharashtra coast. Along northern part of east coast from Kakinada areas also the species is exploited. In Bombay waters it is fished throughout the year and the peak season of fishery extends from January to May. At Kakinada the species is fished mainly during May to September.

15. Macrobrachium rosenbergii (de Man)

Distribution

Widely distributed in Indo-Pacific zone, the western most limit of distribution being the Indus delta. Towards the east the distribution extends upto Indo China. However, the species has, in recent years, been introduced in Hawaii and other areas for aquaculture purposes.

In Indian waters it is found to occur along both the coasts, on the west coast from Indus delta to Malabar delta and also in deltaic Bengal. In the backwaters and Pamba river system of Kerala and in the Hooghly estuarine system it supports good fisheries.

Bionomics and life history

The larval history of the species was described from Malaya by Ling (1962). Later on several authors from different parts of the world including India succeeded in rearing the species through the larval stages in laboratory tanks. Commercial scale rearing of the larvae also is being carried out in some places. All larval stages are active and planktonic in habit. There are 13 zoeal stages before reaching the juveniles stage, in about 45 days. The juveniles heave the planktonic habit and settles to the bottom. A nursery ground juveniles was located by Roman (1967) in the upper reaches of Pamba river and the possibility of existence of several such grounds was suggested.

The species is found to be bottom feeder and omnivorous, the principal items of food being debris, crustaceans remnants, molluscan remains, filamentous algae, plant and animal tissues sand etc.

Among fresh water prawns this species grows to the largest size of about 320 mm length. Sexual dimorphism in growth is exhibited, males estimated to attain lengths of 107.0 mm and 149.0 mm at the end of 1st and 2nd years of life and females 82.5 mm, 130.5 mm and 168.5 mm at the 1st, 2nd and 3rd years respectively. Average number of moults in males in 6 and in females 5 in an year, in the case of immature prawns of total length above 30 mm.

The species performs an interesting spawning migration. Generally inhabiting fresh waters it migrates down to the estuarine regions and spawns in areas where salinity fluctuates between 5.0 to 20.0%. After the young ones grow to a size of 2.0 to 3.0 cm they migrate up the estuary to the fresh water habitats.

The fecundity of females vary with sizes, the number of eggs ranging from 70,000 to 5,00,000. It lays eggs 3 or 4 times in one year. In Kerala the spawning season is from August to December, with peak in October-November. In Hooghly estuary the spawning season is from December to July, peak spawning taking place in March to May.

Population

In Pamba river system males outnumber females in May-June. But from August females predominate and continues so up to October. Then males once again become numerous. In Hooghly estuarine system percentage of females is higher in bigger size groups. Rao (1962) reported instances of sex reversal in laboratory rearing experiments.

Two year groups are reported to be represented in the population of Pamba river system, while in the Hooghly estuarine system 4 year classes are reported. Linear length weight relationship is recorded by several authors.

Exploitation

The species supports a lucrative fishery in the Pamba river system and the adjoining backwaters in central Kerala. The Hooghly estuarine system and the bheris is in Bengal support good fishery. In Kerala the fishery commences in May-June reaches the peak in July-August and September and then decline, lasting upto November. In Bengal the main

fishery lasts from May-June to December with the peak in August to November. The estimated annual production from 1957 to 1962 in Kerala backwaters show that the catches remained steady around 300 tonnes.

Lings studies in Malaya showed the possibilities of developing aquaculture of the species and in places like Hawaii this has been developed to a considerable extent. In India also hatchery production of seed for culture has been achieved.

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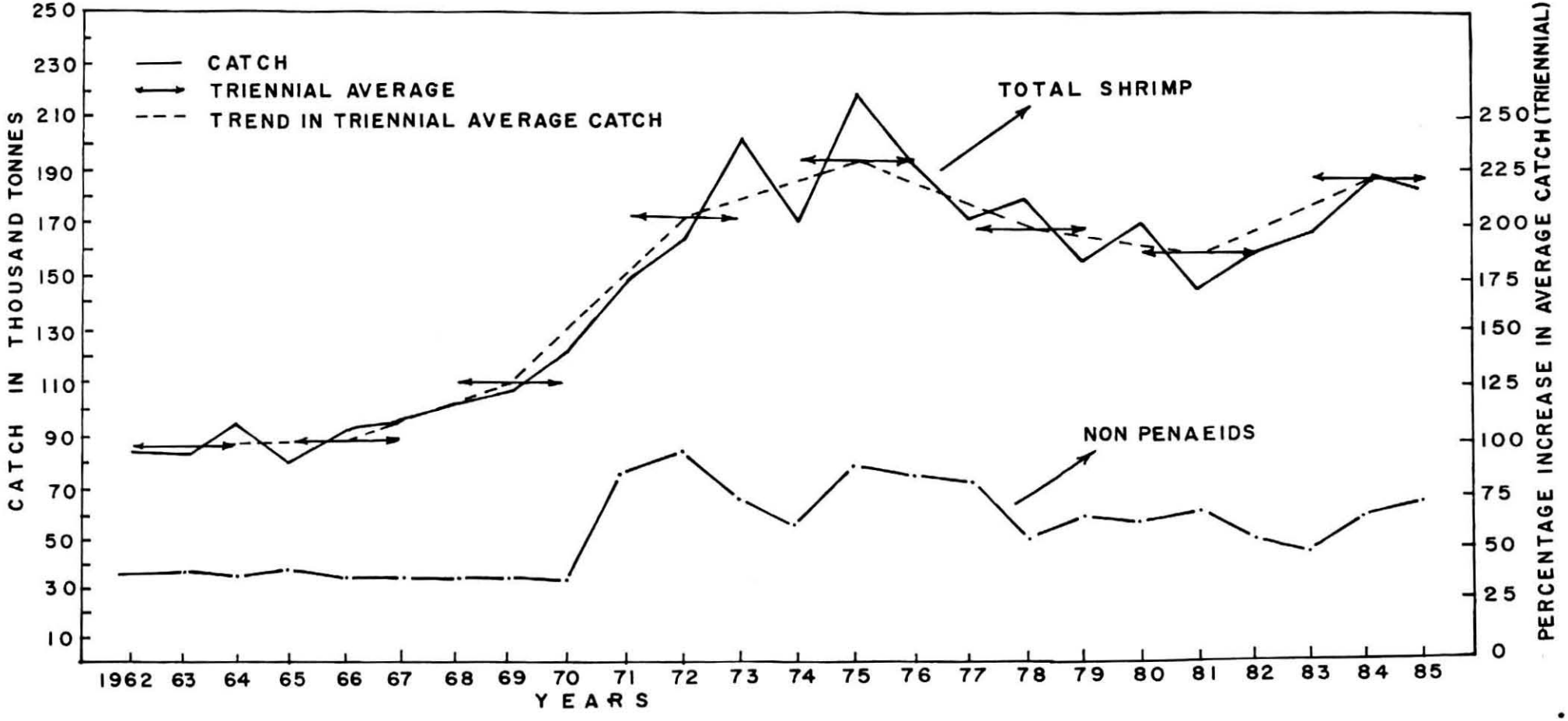

Fig 1. Trend in catch and triennial average catch of shrimps in India (1962—85)

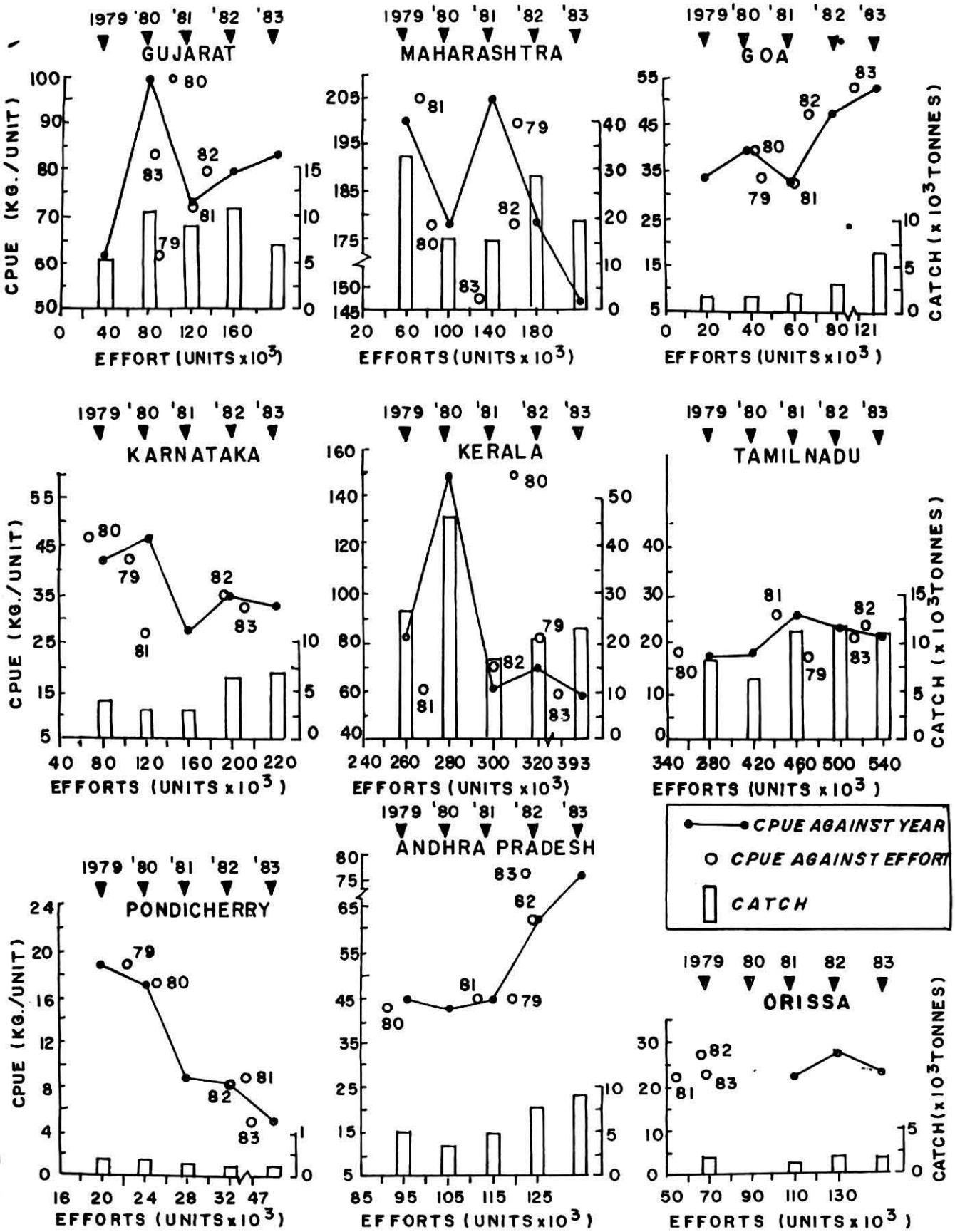

Fig 2. Catch and effort of shrimp Fishery in different maritime states of India during 1979 to 1983.